Instruments

THE MAGAZINE OF MEASUREMENT
INSPECTION · TESTING · CONTROL

ncluding the

JOURNAL OF THE INSTRUMENT SOCIETY OF AMERICA (Page 1267)

nd the

JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION (Page 1279)

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n-the-job Training

nstrumentation, Art and Science

nstrument Electronics

ositive Liquid Meters

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he Neg'ator

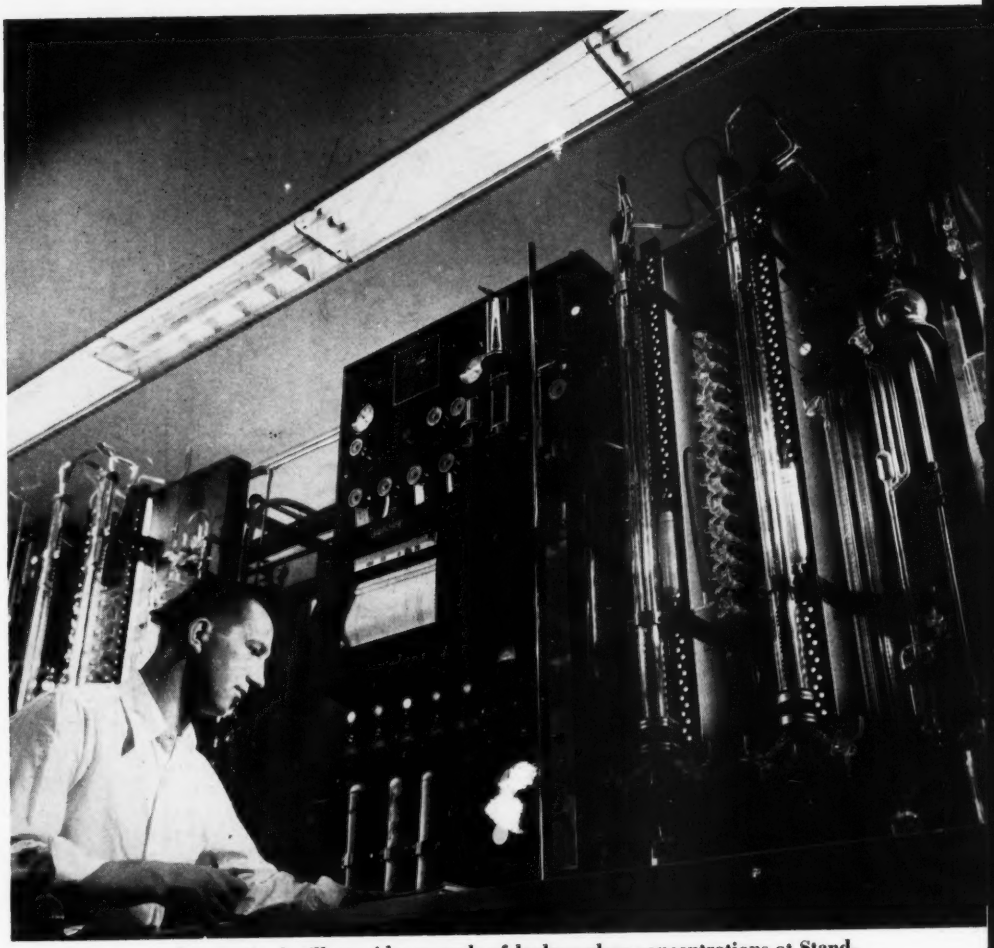
HF Transistor

29 New Instruments

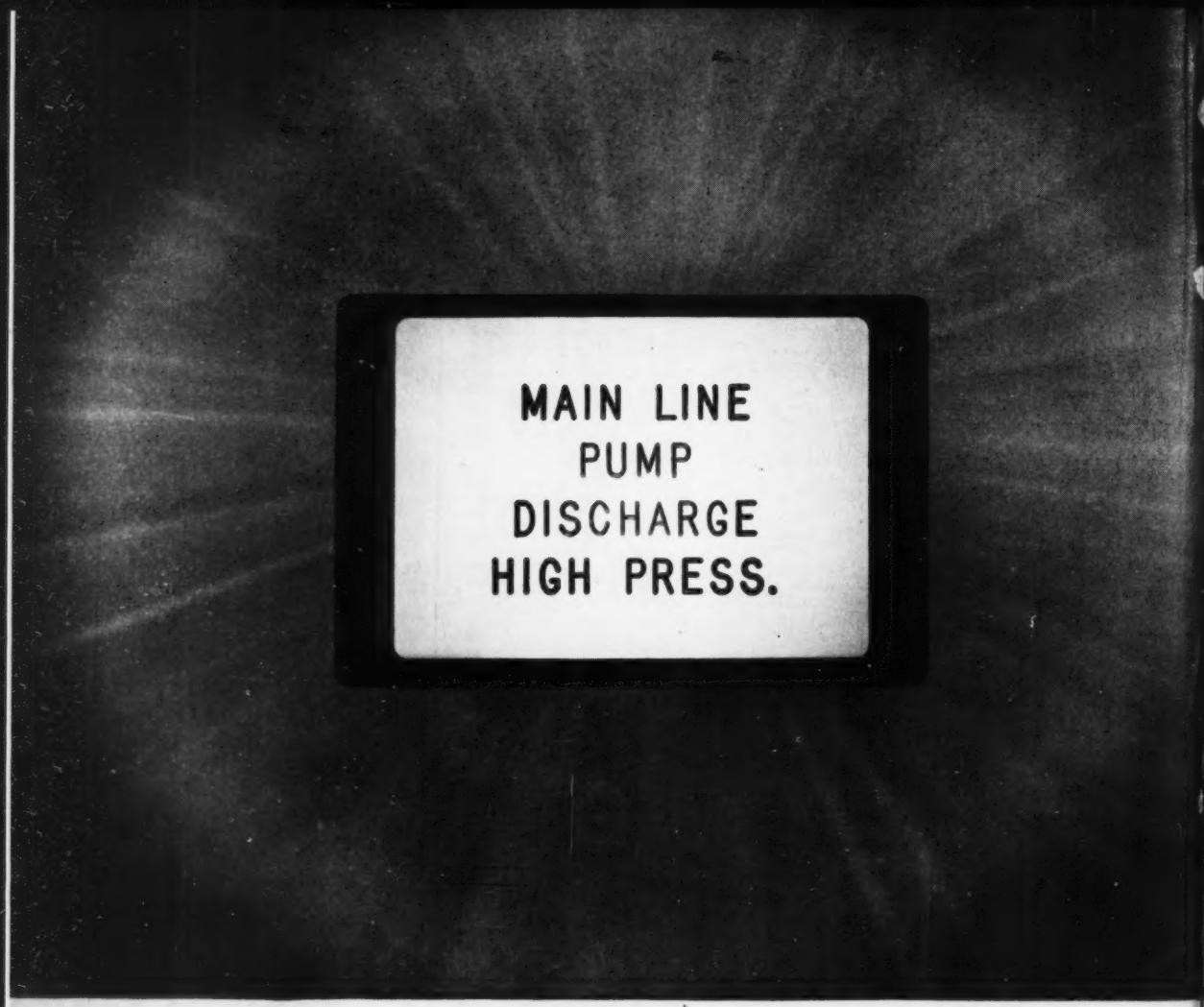
07 New Bulletins

ol. 25 No. 9

EPTEMBER • 1952



Automatized still provides records of hydrocarbon concentrations at Standard Oil Co. of Indiana. ***(Photo courtesy Brown Instrument Div., M-H)***



. . . when something goes wrong

Beyond doubt, the more intricate our processes become . . . the more complex instrumentation grows . . . the more we must engineer for the time *when something goes wrong.* The complete push-button, unattended, continuous processing plant is still in the future.

Today, while we are still using inferential methods of measuring most variables . . . while there are variations in feed composition . . . while there is the possibility of sticking valves, or ever-present corrosion . . . *something will* go wrong.

The products of these three associated corporations, PANELLIT, PANALARM, and PANASCAN, serve regular operating functions in modern control systems. Quality and efficiency considerations make even minor disturbances significant to the process operator.

The true value of this equipment is in achieving a clear, natural co-ordination between the operator and the giant processes he controls.

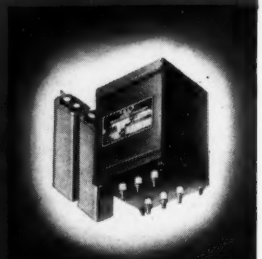
HERMETICALLY SEALED

SOLA *Constant Voltage* TRANSFORMERS

FOR USE ON MIL-T AND JAN PROJECTS

The patented SOLA Constant Voltage Principle provides the following advantages over ordinary transformer design: regulation within ±1% with total primary variations as great as 30% . . . automatic, instantaneous regulation . . . freedom from moving parts, maintenance and manual adjustments . . . self-protection against short circuit. They are available in a complete range of capacities and special types (such as frequency compensated or with harmonic filter).

SOLA Constant Voltage Transformers are made under one or more of the following Patents: 2,143,745 2,192,190; 2,344,421



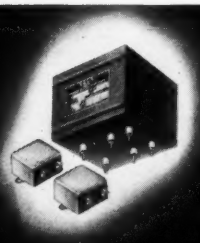
Today's complex electrical and electronic defense equipment requires unfailing accuracy and dependability under extreme conditions of humidity, heat, mechanical shock and other adverse conditions. To meet those needs SOLA voltage regulators can be provided in hermetically sealed housings which conform to defense specifications for grades 1, 2 or 3 hermetic sealing. Splash proof design housings are provided for large units where hermetic sealing is not feasible.

SOLA Constant Voltage Transformers were widely employed during World War II wherever continuous precision performance of electrical and electronic units was mandatory. Typical defense applications include: observation and fire-control, radar, omni-directional ranges and other navigation aids, X-ray equipment, flight and navigation trainers, and photo-electric devices.

Often the precise voltage input upon which a device's design was predicated is not available. Yet, input voltage level must continuously meet design requirements for satisfactory performance. You can guarantee optimum performance for your unit by stabilizing input voltage with a SOLA Constant Voltage Transformer.

WRITE ON YOUR LETTERHEAD FOR BULLETIN GCV142

Typical types of Hermetically Sealed SOLA Constant Voltage Transformers



A portion of Sola's total output capacity is available for production of quantities of conventional military electronic transformers on prime or sub-contract for builders of electronic gear. There are no "standard" designs. Each such contract is individually negotiated, and the transformers are designed to meet the contract specifications. Your inquiry will receive prompt attention.

SOLA *Constant Voltage* TRANSFORMERS

Transformers for: Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Airport Lighting • Series Lighting • Luminous Tube Sign • Oil Burner Ignition • X-Ray • Power • Controls • Signal Systems • etc. • SOLA ELECTRIC COMPANY, 4633 W. 16th Street, Chicago 50, Illinois

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and CONTROL BOARDS

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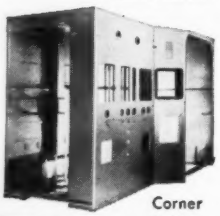

Five Section Cubicle Control Board and Lighting Canopy

Corner Cubicle Section

Refinery Cubicle with Mimic Flow Diagram in Color

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Experienced designing and quality fabrication assure the efficiency of any indicating, recording, or control installation. Whether you are planning new construction, modernizing existing installations or adding to present equipment, FALSTROM offers long years of experience and the most modern facilities for fabricating to your specifications or recommending standard designs. In any case, by specifying FALSTROM you specify the highest possible quality metal working techniques known to the industry. Estimates on your needs will be supplied promptly—call or write FALSTROM to arrange a consultation.

WRITE FOR BULLETIN #125

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Instruments

THE MAGAZINE OF MEASUREMENT INSPECTION · TESTING · CONTROL

Vol. 25 SEPTEMBER 1952 No. 9

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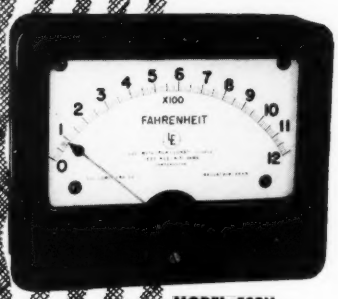
FOR TEMPERATURE TESTING IN THE LABORATORY OR IN THE PLANE . . .

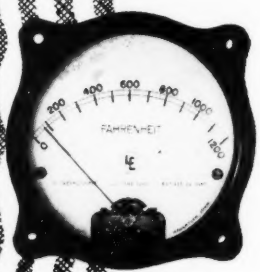
Constructed with the same care as our aircraft temperature indicators, these pyrometers bring "aircraft quality" to the test engineer. Use Lewis leads, thermocouples and selector switches to build complete temperature measuring installations. All models available with black dials and white markings for photographic observers.



MODEL 58PY

This instrument has been used extensively by the leading motor-car manufacturers for road testing on the "Proving Grounds" — where performance counts. Housed in a rectangular bakelite case, this reliable, fully compensated pyrometer is furnished with 6 in. hand drawn scales for greater accuracy. The Model 58PY is available for use with all standard thermocouple materials, in many ranges to suit the most exacting application.

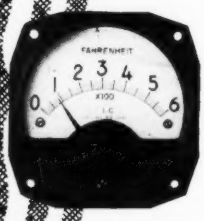
Accuracy — 1% of total scale deflection



MODEL 23B

Manufactured with the same type of movement as our aircraft pyrometers, the Model 23B pyrometer is well suited for use in moving vehicles and has been successfully used in many test stand installations. It is housed in a 4 in. round bakelite case that is flanged for panel mounting, and is available in several ranges for use with various thermocouple materials.

Accuracy — 2% of total scale deflection



MODEL 20B

The Model 20B series of indicators are patterned after our standard aircraft instruments and are supplied with 3" round steel cases suitable for panel installation. These compact, sturdy indicators have 2⅛ in. scales, are fully cold-end compensated and are available in many ranges for use with various thermocouple materials.

Accuracy — 2% of total scale deflection

STANDARD RANGES, ALL MODELS

FAHRENHEIT		*CENTIGRADE*	
0 to 400	0 to 1200	0 to 200	0 to 600
0 to 600	0 to 1600	0 to 300	0 to 800
0 to 800	0 to 1800	0 to 400	0 to 1000
0 to 1000	0 to 2000	0 to 500	0 to 1100
0 to 2500		0 to 1400	

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Manufacturers of *Complete* Temperature Measuring Systems for Aircraft

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MEASURE AIR VELOCITY DIRECTLY AND ACCURATELY

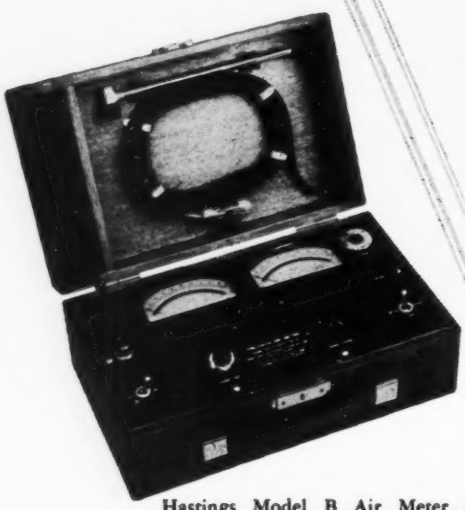
WITH A

HASTINGS AIR-METER

Hastings Model H Air Meter. Compact unit for field and laboratory use. Velocity Ranges: 10-750 fpm; 750-5500 fpm.

The most sensitive of all air meters for research, industrial and agricultural applications. Reads directly in feet-per-minute on a logarithmic-type scale expanded at lower velocities. Highly sensitive — will indicate the velocity of smoke rising from a cigarette. Response time less than one second. Accurate to within ± 2% regardless of ambient temperature or static pressure.

Uses the exclusive Hastings noble metal thermopile in an extremely stable circuit. Instantaneous range switching without recalibration. Probes available for directional or non-directional reading. Easily adapted for remote recording since the calibration is independent of lead length. Available in several models to meet your specific requirements.



Hastings Model B Air Meter for measurements of greatest precision. Velocity ranges: 0-400 fpm; 400 to 6,000 fpm. Meter type continuous calibration check. Knife edge, parallax free indicator.

Hastings Model G Air-Meter. Small hand type instrument. Velocity range: 0-6000 fpm; Weight: 26 ounces.

Write for descriptive literature and prices on Hastings Air Meter, Manometer and Flowmeters, and Vacuum Gauges.

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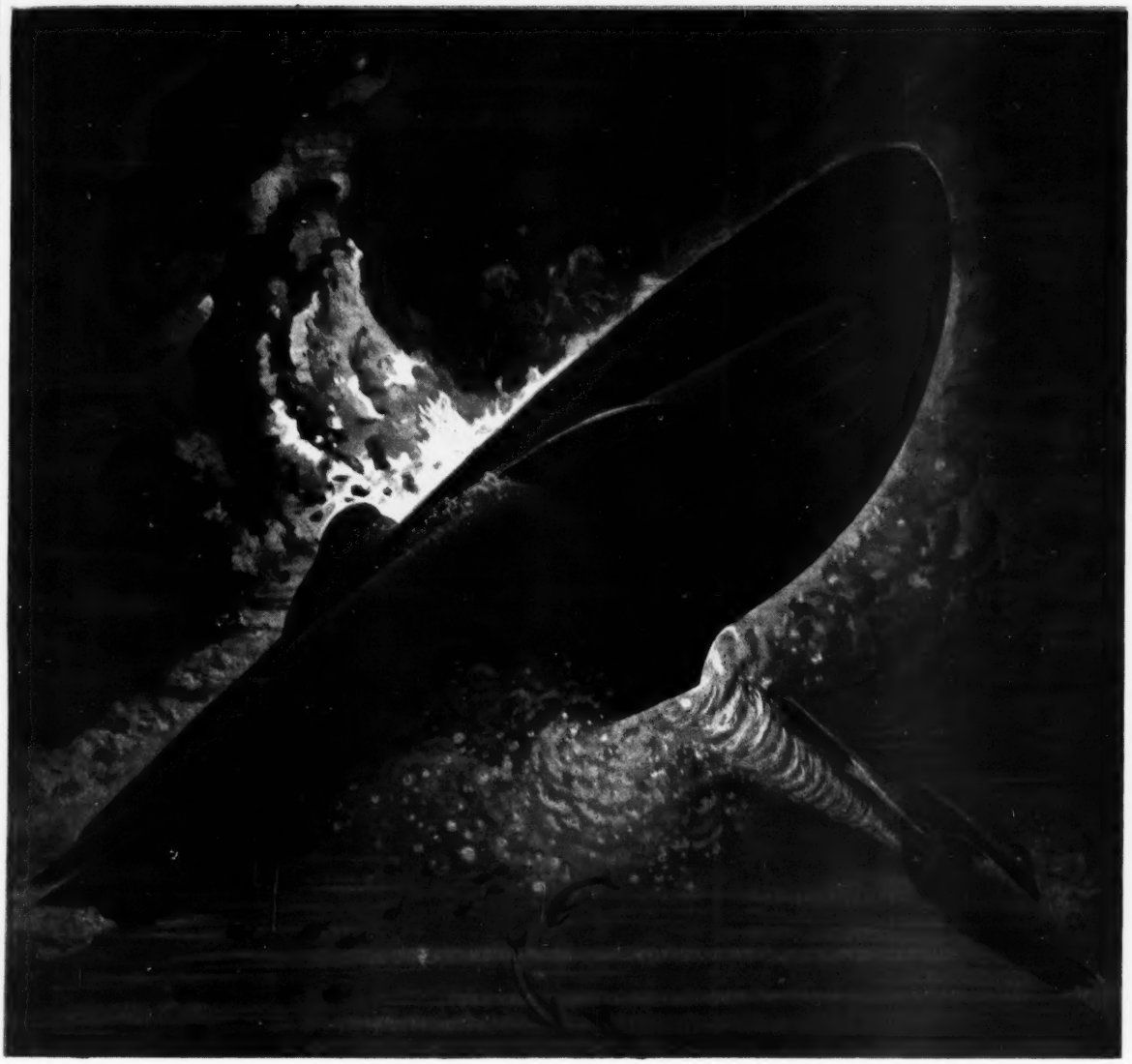


Deep-sea dog fight

Our sea battles of the future may be fought by high-speed submarines on the eeriest battleground of all time—deep beneath the sea. For the first time in naval history submarines are now being designed expressly to track and destroy other submarines while totally submerged.

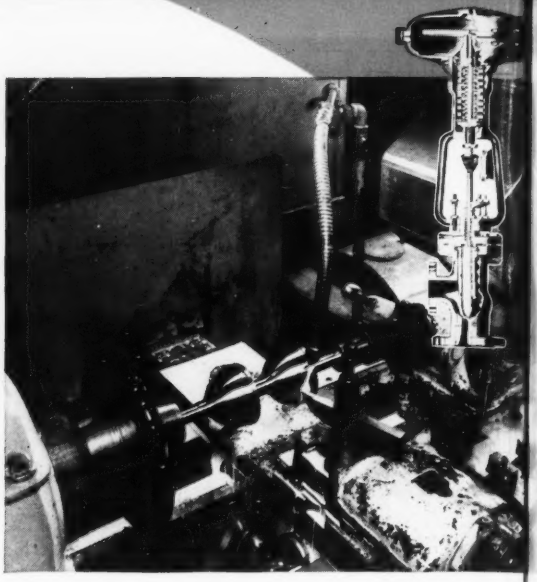
The detection and missile-guiding systems which make this possible are the result of bringing the magic of electronics to problems of automatic control and computation too complex for rapid solution by man. Working closely with the Armed Forces for 34 years, Arma Corporation has played a leading part in this field in basic research, design, development and production.

Electronics provides a whole new arsenal of defense weapons. In important areas of this field Arma is pacing the developments. *Arma Corporation, Brooklyn, N. Y.; Mineola, N. Y.; Subsidiary of American Bosch Corporation.*

ARMA ADVANCED ELECTRONICS FOR CONTROL

Close Tolerances at the BS&B Climax Controls Factory

1.



You demand controls designed and engineered by men thoroughly familiar with your industry. You demand the manufacturer be stingy with his tolerances . . . a stickler for exacting accuracy for you know that on such accuracy may depend your cost of operation—the safety of your equipment—the lives, even, of your people.

That's why we know we're being complimented when so many precision minded industries rely so completely on BS&B Climax Controls—they **trust** our knowledge and above all, our **care** in manufacture. BS&B Climax engineers protect this enviable reputation by constantly watchdogging the production of the Climax instrument that safeguards your control of pressures, temperatures, levels and flow.

And safety is not the only benefit Climax Controls may give you. Wide awake industries have found that Climax valves, controls, regulators or relays can in many cases . . . (a) eliminate manual operations, (b) vary, increase or multiply the functions of equipment, (c) supply additional safety factors, (d) reduce supervisory requirements.

2.

Generous Control Performance

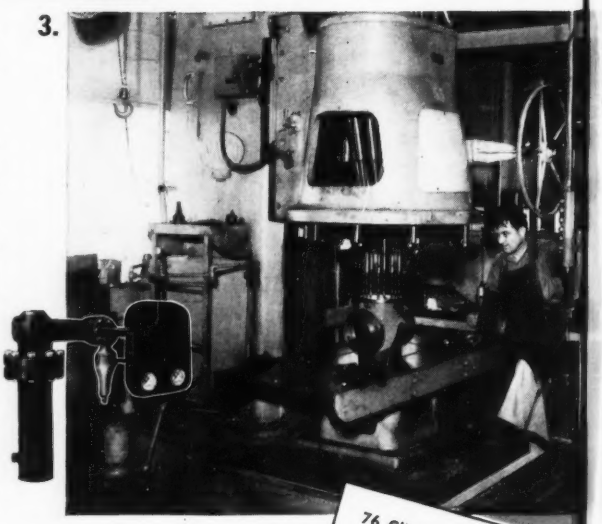
Performance and reliability show up in the manufacturing of Climax Controls. Here are a few of the steps that enable us to turn out over 12,000 different parts used in the assembly of various Climax Controls.

1 **"Peas-in-a-pod" Uniformity.** An electronic-hydraulic duplicator reproduces every inner valve from a template within .001" tolerance, assuring uniform inner valve characteristics.

2 **Part of the modern and orderly Climax Controls** factory . . . milling machines, deburring and grinding bench, drill presses and boring mill. Skilled and experienced operators contribute heavily to your control application where the name Climax appears.

3 **Applying Craftsman's touch to Mass Production.** For economy, which is passed along to you, Climax Controls are produced on an assembly line basis . . . for accuracy, which you enjoy in true performance, a Climax Control is never without the Craftsman's touch. Here a large multiple spindle drill works true bolt circles in a large body. A similar but smaller unit does the same job for smaller parts.

3.



EFFICIENCY BS&B RELIABILITY OUR 50TH YEAR

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The Hagan THRUSTORQ translates a force or weight into a pneumatic signal pressure. This pressure reports the force or weight accurately and dependably to indicating or recording instruments, or to an automatic control system.

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- testing piston rings
- jet engine thrust measurement
- rocket thrust measurement
- spring testing machines
- automatic batch weighing
- dynamometer testing of electric motors, hydraulic pumps or internal combustion engines

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measuring thrust and torque *with air!*

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Major oil companies select Masoneilan Control Valves for service thousands of miles away because they *know* from extensive experience at home and abroad that they can rely on these valves for accurate, *dependable* performance. For the same reasons, many hundreds of Masoneilan 12000 Series Liquid Level Controllers have been selected for these expansion programs. You, too, should know about the design and construction features, initiated and developed by field experience, which make these Masoneilan products first choice all over the world.

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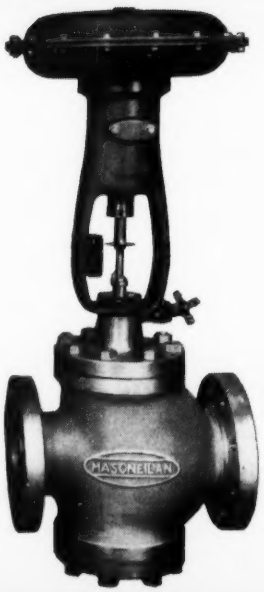

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FOR SMOOTH, DEPENDABLE

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• S-m-o-o-t-h action . . . that's an indication of the close, evenly graduated electrical control provided by every Ohmite rheostat. This smoothness is a result of their distinctive design, incorporating a wobble-free brass bushing for effortless shaft rotation, tempered steel contact arm assuring uniform brush pressure, and smoothly gliding metal-graphite brush.

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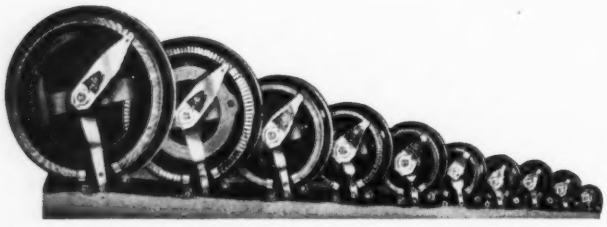
Write on company letterhead for catalog and engineering manual No. 40

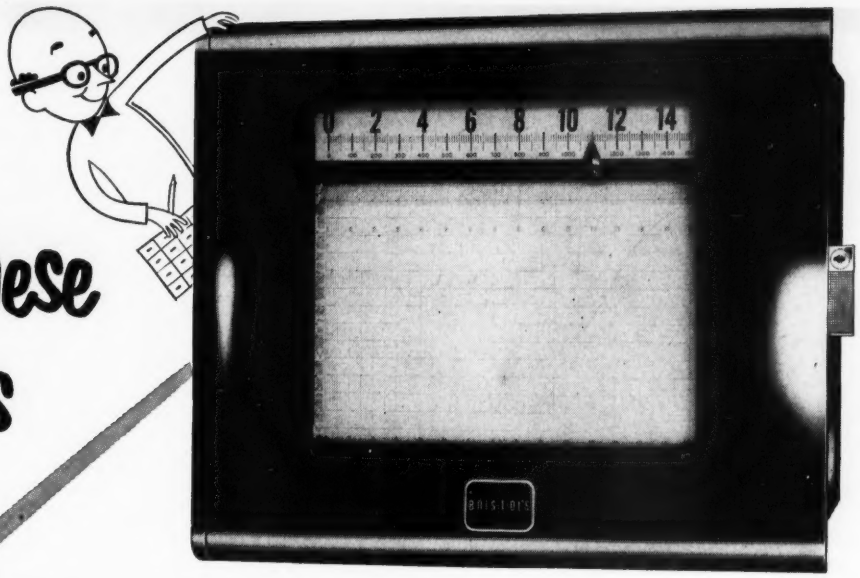
Ohmite Manufacturing Co.
4886 Flournoy St., Chicago 44, Illinois



Ohmite offers the most extensive line of rheostats on the market . . . ten sizes, from 25 to 1000 watts, in a complete range of resistance values.

OHMITE.

first **IN WIRE-WOUND RHEOSTATS AND RESISTORS**



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✓ All types of electric and air-operated controllers offered

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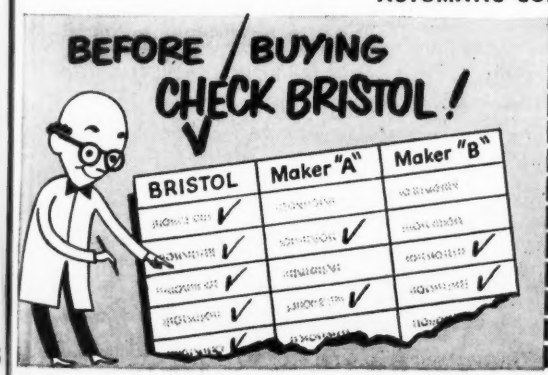

THE BRISTOL COMPANY
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Waterbury 20, Conn

Please send catalog giving details of Dynamaster performance to:

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Engineers and process operators can save themselves a lot of time and energy in running tests when they use Speedomax Electronic Indicators for "round-up" checks of temperature and other process conditions.

A flick of the finger connects the desired sensing element to the Indicator . . . the instrument's calibrated drum whirls to the reading . . . the drum stops dead still. The entire operation takes only 4½ seconds for consecutive readings at opposite ends of the scale. Minimum time for close-together points is only a fraction of a second. Logging time depends only on the writing speed of the operator.

126 COUPLES ON ONE INDICATOR

As many as 126 thermocouples may be connected to one Indicator without the use of side panels; with panels the number increases indefinitely. This total of 126 requires toggle-type switches on the Indicator; for rotary and push button switches the totals become 96 and 48. Push buttons are normally supplied with interlocks to assure one-at-a-time operation, but when desired the interlocks can be disconnected so that several switches may be closed simultaneously, causing the instrument to give the average of those points.

As many as 96 Thermohm electrical resistance thermometers may be connected to the Indicator, using either toggle or rotary switches.

Because the Indicator's scale is not a disc, but the rim or "tread" of a drum-like wheel, the calibration lines are non-radial and hence unusually easy to read. The drum's 25-inch scale has an average of 300 divisions . . . can have 500 if necessary. Enclosed slidewire, and thorough shielding against stray fields, are typical details of high-quality construction.

The equipment is described in our Catalog ND46(1). Whether or not you require this information at present, we will be glad to send a copy for reference. Address our nearest office, or 4955 Stenton Ave., Philadelphia 44, Pa.

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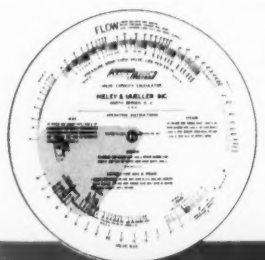
All over the country leading companies in the process industries are solving tough problems with K & M control valves, designed especially for precise and positive control by instrumentation.

More and more, as the outstanding performance of these superbly engineered valves becomes known, important companies with pressure and flow applications are turning to K & M for the skill, knowledge and experience that assure reliable automatic control of pressures, temperatures, rates of flow and liquid levels.

There is a qualified K & M representative near you, eager to discuss your control problems and able to provide the most satisfactory solution.



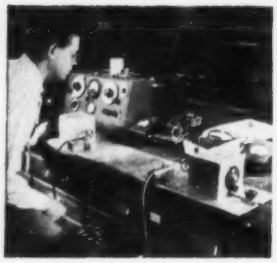
This extremely accurate circular slide-rule type K & M valve capacity calculator includes correction scales for steam quality, liquid and gas specific gravity and a flowing temperature scale for gases. Sent without charge in response to a request on your business stationery.

K&M

KIELEY & MUELLER, INC.

Valve Makers Since 1879

2033 - 43rd STREET NORTH BERGEN, N. J.



LABORATORIES: Experimental and development work requires extremely close voltage control for accurate and dependable results.

MANUFACTURING: To achieve maximum rated performance of electrically powered equipment, the input nameplate voltage must be maintained.

TESTING: Constant voltage must be maintained when testing or inspecting your product to obtain a valid check.

MAINTENANCE: By maintaining constant voltage to lamp loads and electrically operated equipment, productive life is increased and maintenance costs reduced.

ELECTRICAL OPERATIONS IN *Your Plant* REQUIRE

STABILINE

Automatic

VOLTAGE REGULATORS

TYPE EM4115

TYPE IE5101R

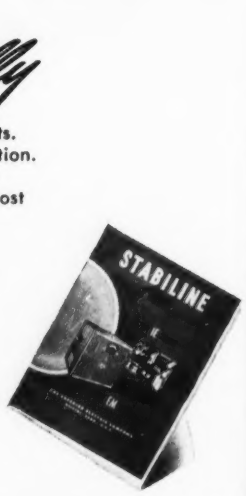
THERE IS NO BETTER WAY TO MAINTAIN CONSTANT OUTPUT VOLTAGE *Automatically*

TYPE IE — **INSTANTANEOUS ELECTRONIC**

Completely electronic automatic voltage regulators with no moving parts. Offer instantaneous correction . . . excellent stabilization and regulation. Waveform distortion does not exceed 3%. Particularly adapted for use in laboratories . . . test lines and for all other applications where the most exacting voltage regulation is necessary.

TYPE EM — **ELECTRO MECHANICAL**

Consists basically of a very sensitive detector controlling a motor-driven POWERSTAT variable transformer and auxiliary transformer. Correction is not instantaneous but is faster than most automatic voltage regulators. Features zero waveform distortion and high efficiency. Ideally suited for controlling large industrial loads.



FOR YOUR ELECTRICAL OPERATIONS . . .

. . . there is a STABILINE Automatic Voltage Regulator right for the job . . . to maintain constant voltage regardless of line or load changes.
Send today for complete information.

WRITE TO — 709 THURE AVENUE, BRISTOL, CONNECTICUT
ASK FOR — SECO BULLETIN S351

THE SUPERIOR ELECTRIC CO.
BRISTOL, CONNECTICUT

- STABILINE AUTOMATIC VOLTAGE REGULATORS
- POWERSTAT VARIABLE TRANSFORMERS
- VARICELL D-C POWER SUPPLIES
- VOLTBOX A-C POWER SUPPLIES
- SUPERIOR 5-WAY BINDING POSTS
- POWERSTAT LIGHT DIMMING EQUIPMENT

Modern Safeguards—Brink's for Money, Bailey for Process Materials

Are Your Process Materials Guarded As Well?

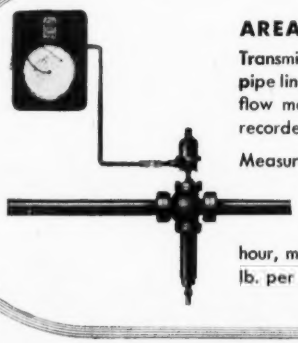
HERE'S HOW TO PREVENT SPOILAGE AND WASTE . . .

TO avoid waste of valuable process materials and finished products, process rates and conditions must be accurately measured and controlled. That's where Bailey Meters, Analyzers and Controllers can help you to improve the efficiency of your plant.

Take flow for instance. Bailey Meter Company offers a complete line of flow measuring and controlling equipment for applications ranging all the way from high pressure steam to low pressure gas. We measure flow in pipes, open channels, ducts, furnaces, smelters, kilns, ovens, dryers.

When you call Bailey Meter Company, you get the help of years of experience as well as recommendations from a wide selection of measuring and controlling devices.

Your local Bailey Engineer is as near as your telephone. He has the experience and the equipment necessary to set up an effective guard for your process materials. P-26



AREA TYPE FLOW METER

Transmitter goes into 1, 2 or 4 inch pipe line like a valve and transmits flow measurements electrically to recorder in remote location.

Measures oil and other clear liquids under static pressures up to 600 psi. Minimum range 0 to 1200 lb. per hour, maximum range 0 to 9600 lb. per hour.

BAILEY METER COMPANY

1041 IVANHOE ROAD
CLEVELAND 10, OHIO

Process Controls
TEMPERATURE · FLOW
PRESSURE · LEVEL
GAS ANALYSIS · RATIO

a new draft gage!

easy to remove separate units

easy to read— no glare, no parallax

Available in four mountings

Semi-flush mounting

Eye-level mounting

Recessed mounting

Projected mounting

easy zero check from the front

exclusive magnetic access door—no screws, latches, handles

the HAYS Vertiscale

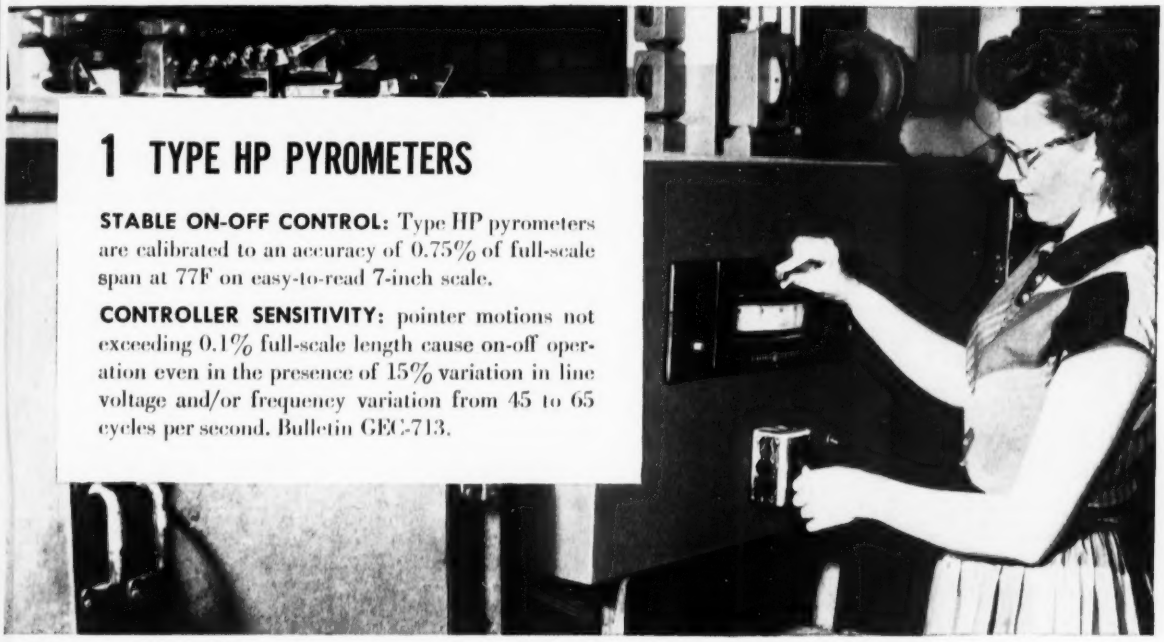
You designed this draft gage! You asked for these features!
Accessibility from the front makes possible easy "one man" method of quickly checking zero. (The fast 3-way cock with test fitting is *standard* on the Hays Vertiscale).
Simple maintenance—individual units can be quickly removed for inspection or adjustment. Removal does not affect other units in the case, does not disturb calibration of unit being re-installed.
No parallax—design eliminates reflections regardless of viewing angle.
No glare—internal fluorescent lighting is standard.
You get all these values *plus* functional styling in the Hays Vertiscale draft gage!
Write today for full information on the Hays Vertiscale Bulletin 52-1060-210.

Automatic Combustion Control
Boiler Panels • Hays-Penn Flowmeters
Veriflow Meters and Veritrol
Gas Analyzers • Draft Gages
Combustion Test Sets • CO_2 Recorders
Electronic Oxygen Recorders

THE hays CORPORATION

MICHIGAN CITY 8, INDIANA

Control Process Temperatures Precisely With G-E Pyrometers that Fit the Job



1 TYPE HP PYROMETERS

STABLE ON-OFF CONTROL: Type HP pyrometers are calibrated to an accuracy of 0.75% of full-scale span at 77F on easy-to-read 7-inch scale.

CONTROLLER SENSITIVITY: pointer motions not exceeding 0.1% full-scale length cause on-off operation even in the presence of 15% variation in line voltage and/or frequency variation from 45 to 65 cycles per second. Bulletin GEC-713.

2 TYPE FH-1 HAND PYROMETER

QUICK, EASY TEMPERATURE CHECK: Two scale ranges of 0-500F and 0-1500F make a variety of temperature measurment possible with the FH-1. Simply flick a switch to change scales.

INTERCHANGEABLE TIPS: 3 different ones, for measuring temperatures of solids, liquids, and gases. Bulletin GEC-836.

FOR MORE INFORMATION write or call your nearest G-E apparatus sales office or authorized agent or distributor. For bulletins write to Section 602-244, General Electric Co., Schenectady, N. Y.

GENERAL ELECTRIC

Here's why

it pays to know your

HSM

HONEYWELL SUPPLIES MAN

Brown thermocouple wells are precision-machined to highly uniform wall thickness . . . your guarantee of dependability at high temperatures and pressures; supplied in all common metals and alloys, in wide range of sizes and wall thicknesses.

C. J. SMOLINSKE, Honeywell Supplies Man in the Indianapolis area, explains to Mr. Leon Stewart of the Rock Island Refinery the construction features of Brown precision-made thermocouple wells . . . and the convenience features of the HSM plan for buying pyrometer supplies.

You'll be pleasantly surprised when you, too, learn how this *plan* can add new convenience and economy to *your* supplies purchasing!

There's a Honeywell Supplies Man near you . . . at your local Honeywell office . . . as close to you as your phone. Call him in today, and find how planned buying . . . *the HSM way* . . . can work in your plant.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4482 Wayne Ave., Philadelphia 44, Pa. Stocking points in Philadelphia, Cleveland, Chicago, Atlanta, Houston, Los Angeles, and San Francisco.

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS

● *Important Reference Data*

First in Controls

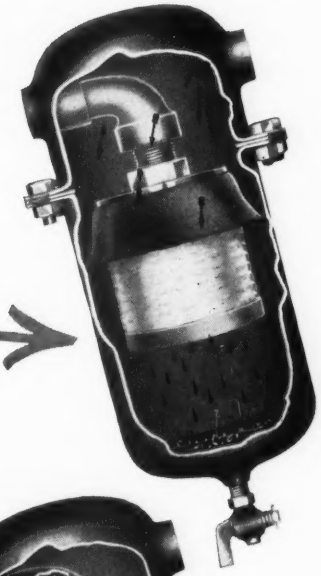
WRITE FOR CATALOG 200-2 ON THERMOCOUPLE WELLS . . . AND FOR NEW PYROMETER SUPPLIES BUYERS' GUIDE NO. 100-4

STAYNEW FILTERS' DOUBLE ACTION

Guards Against Water, Oil and Pipe Scale

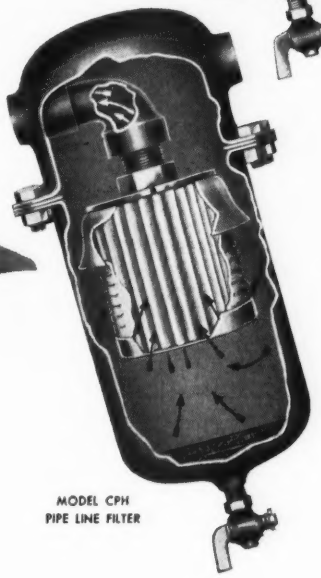
MECHANICAL SEPARATION

1. Deflector cup directs flow of air or gas together with water, oil and dirt to the walls of the housing and then downward at high velocity into the base where liquid and heavier dirt particles are deposited.



FILTRATION

2. Air or gas, having been mechanically cleaned, rises at low velocity through the Radial Finned Filtering element or insert which removes the lighter air-borne material.



MODEL CPH
PIPE LINE FILTER

This exclusive Double-Action principle of Staynew Pipe Line Filters assures sustained, trouble-free operation. Inexpensive, quickly installed and easily maintained, these filters keep air operated or controlled equipment free from pipe scale, dust, dirt, and condensate. Wherever you require air and other gases *clean* and *dry*—demand and get—Staynew Pipe Line Filters.

Write today for complete Staynew Pipe Line Filter Bulletin B-1A.

Representatives in Principal Cities

DOLLINGER PROTECTOMOTOR STAYNEW FILTERS

DOLLINGER CORPORATION

63 Centre Pk., Rochester 3, N. Y.

ALL TYPES OF FILTERS FOR EVERY INDUSTRIAL NEED

Anything You May Need in TAPE-WOUND CORES

RANGE OF MATERIALS

Depending upon the specific properties required by the application, Arnold Tape-Wound Cores are available made of DELTAMAX . . . 4-79 MO-PERMALLOY . . . SUPERMALLOY . . . MUMETAL . . . 4750 ELECTRICAL METAL . . . or SILECTRON (grain-oriented silicon steel).

RANGE OF SIZES

Practically any size Tape-Wound Core can be supplied, from a fraction of a gram to several hundred pounds in weight. Toroidal cores are available in fifteen standard sizes with protective nylon cases. Special sizes of toroidal cores—and all cut cores, square or rectangular cores—are manufactured to meet your individual requirements.

RANGE OF TYPES

In each of the magnetic materials named, Arnold Tape-Wound Cores are produced in the following standard tape thicknesses: .012", .008", .004", .002", .001", .0005", or .00025", as required.

Applications

MAGNETIC AMPLIFIERS
PULSE TRANSFORMERS
CURRENT TRANSFORMERS
WIDE-BAND TRANSFORMERS
NON-LINEAR RETARD COILS
PEAKING STRIPS . . . REACTORS.

WAD 3983

THE ARNOLD ENGINEERING COMPANY
SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION
General Office & Plant: Marengo, Illinois

How CROSBY's BALANCED AREA DESIGN eliminates back pressure effects

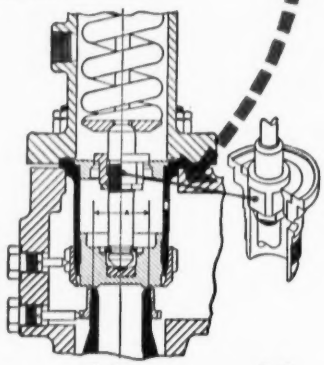


Fig. 1 Fig. 2

When a standard relief valve on gas or vapor service is installed, where back pressure exists, one of two undesirable effects will occur:

Constant Back Pressure — The back pressure acts on part of the upper and the overhanging part of the lower surface of the disc, cancelling out the back pressure force. There remains, however, a force acting on the top portion of disc (area A) which increases the spring load and causes the valve to pop "heavy."

Variable Back Pressure can not be compensated for by spring adjustments. When one or more valves discharge into a common flare header, variable back pressure is placed on the remaining closed valves. This can create a hazardous condition on remaining closed valves, by adding to the spring force. The valve then is prevented from opening until pressure has risen far above the vessel design limit.

The Crosby Balanced Area Design

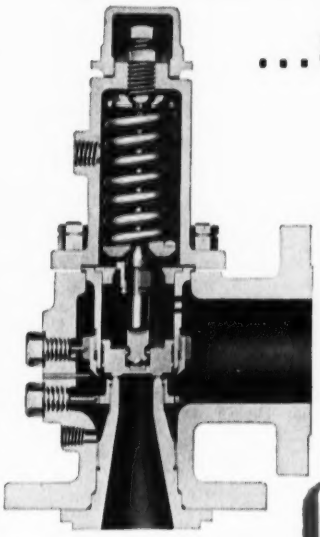
is a simple, foolproof method of nullifying these undesirable effects (see Figure 1 above).

Operation — Crosby achieves *Stable Popping Pressure* by the addition of a piston affixed to the spindle, of area proportioned to equal the unbalanced area of the disc (area A in Fig. 1). Back pressure introduced through the port in the guide then acts on two equal areas in opposite directions, and cancels itself out, neither aiding nor opposing the spring.

To assure full lift and stability, a vent system (see sectional view of piston, Fig. 2) is employed. When the valve is open, the flats on the piston will vent any accumulated back pressure that would tend to close the valve. The adjustment and operating characteristics are similar to the conventional valve. The actual flow into the bonnet is relatively low and can be vented to atmosphere, or through a properly sized discharge header.

Extensive, trouble-free use in the field has proved the success of this Crosby Balanced Area Design.

Here's the CROSBY RELIEF VALVE which eliminates back pressure effects ...and reduces costs!



CROSBY RELIEF VALVE
Style JO-BP
with BALANCED AREA DESIGN
for the elimination
of Back Pressure Effects.

Proved ECONOMY!

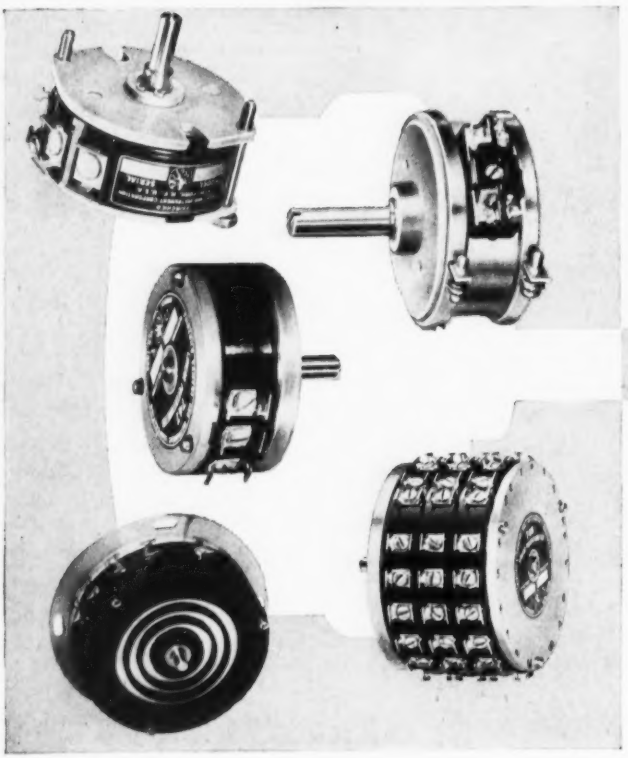
On the many installations where Crosby JO-BP Valves have been in operation, refineries report sizable savings in piping costs. The reason—smaller discharge lines made possible by higher back pressure. Since Crosby JO-BP Relief Valves will handle back pressure surges ranging up to 90% of inlet pressure, smaller diameter discharge pipe carries the same amount over the same distance that formerly required much larger pipe.

Proved PROTECTION!

On-the-job performance of Crosby JO-BP Relief Valves proves that you can depend on the vented Balanced Area Design to operate on the set pressure. Thus you are assured of a *Stable Popping Point*. What's more, a full lift is obtained over the normal range of back pressures. The Crosby JO-BP operates with an unrestricted nozzle, follows standard nozzle flow equations for above or below critical ratio as the case may be. With its vented Balanced Area Design, the Crosby JO-BP provides a foolproof, time-tested method of eliminating back pressure effects.

CROSBY STEAM GAGE & VALVE COMPANY
43 Kendrick Street, Wrentham, Mass.
District Sales Offices:
BOSTON·NEW YORK·CHICAGO·DALLAS·LOS ANGELES

Sample Precision Potentiometers now available in 4 to 6 weeks



Better delivery than ever before of Fairchild Precision Potentiometers is the result of recently improved facilities and additions to personnel. Now you can expect delivery of sample standard units with windings to meet your requirements in 4 to 6 weeks after your final approved specifications are received. The same reasonable prices prevail, too.

Enlargement and realignment of facilities and personnel also enable us to start delivery of production orders in 3 to 4 months after receipt of your order.

Thus, when you look to Fairchild for your precision-potentiometer requirements you get products built to the highest standards of quality coupled with sound engineering help that starts with your idea and carries through to final delivery.

HOW PRECISION IS DESIGNED AND BUILT INTO FAIRCHILD POTENTIOMETERS

1. Shaft is centerless-ground from stainless steel to a tolerance of +0.0000, −0.0002 in. which, together with precision-bored bearings, results in radial shaft play of less than 0.0009 in.

2. Mounting plate has all critical surfaces accurately machined at one setting to insure shaft-to-mounting squareness of 0.001 in./in. and concentricity of shaft to pilot bushing within 0.001 in. FIR.

3. Housing is precision-machined from aluminum bar stock. Close tolerance of this construction permits ganging up to 20 units on a single shaft with no eccentricity of the center cups, even though only two bearings are used.

4. Windings are custom-made by an exclusive technique. This, together with precious metal alloy contacts results in guaranteed accuracies of ±0.5% linear and ±1.0% non-linear in standard type potentiometers. Higher accuracies (to 0.05%) are available in other types.

DO YOU HAVE CONTROL PROBLEMS?

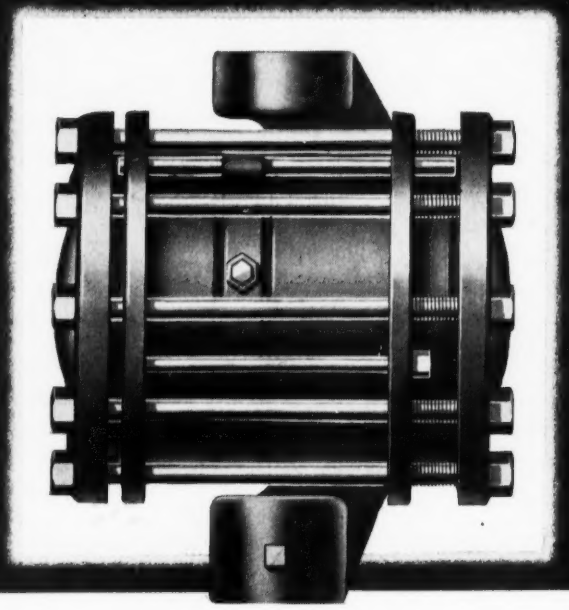
Fairchild Sample Laboratory engineers are available to help you with potentiometer problems. To get the benefit of their knowledge and experience write today, giving complete details, to *Potentiometer Division, Fairchild Camera and Instrument Corporation, Park Avenue, Hicksville, L. I., New York, Department* **140-29B**

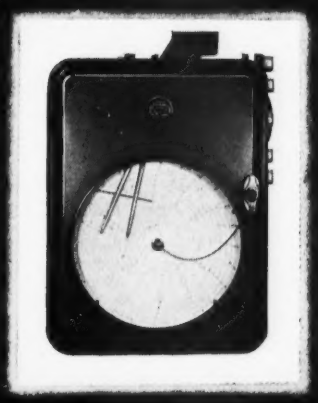
FAIRCHILD
PRECISION POTENTIOMETERS

Now AMERICAN® offers...

THE *NEW* MERCURYLESS DRI-FLO ORIFICE METERS

Easy to Install • Lastingly Accurate • Minimum Maintenance





- **ONE PIECE STAINLESS STEEL BELLOWS—minimizes metal fatigue for long service life.**
- **DIRECT FULL SCALE RECORDING PEN MOVEMENT—no external gearing or linkage multiplication.**
- **STAINLESS STEEL INTERNAL PARTS—and Monel metal stuffing box shaft for corrosion resistance.**
- **AMERICAN TYPE "B" TEFLON SEAL STUFFING BOX—no lubrication, no shaft freezing, no leaks.**
- **STICK PROOF CHECK VALVES—protect bellows against over-range damage or distortion.**
- **SIMPLIFIED RANGE CHANGE—no disconnecting manifolds.**
- **EASY CALIBRATION AND CLEANING—by simply removing one or both case cover heads.**

NO PRECISE LEVELLING OR SEAL POTS REQUIRED.

FOR PEDESTAL, PANEL OR OVERHEAD MOUNTING—TOP OR BOTTOM GAUGE LINE CONNECTIONS.

Dri-Flo Meters are the latest addition to the American line—developed under the Company's century-old tradition of "Sustained Accuracy at Lower Cost."

Write for Specifications

AMERICAN METER COMPANY
INCORPORATED ESTABLISHED 1836

AMERICAN METER CO. EST. 1836 MEASUREMENT ENGINEERS

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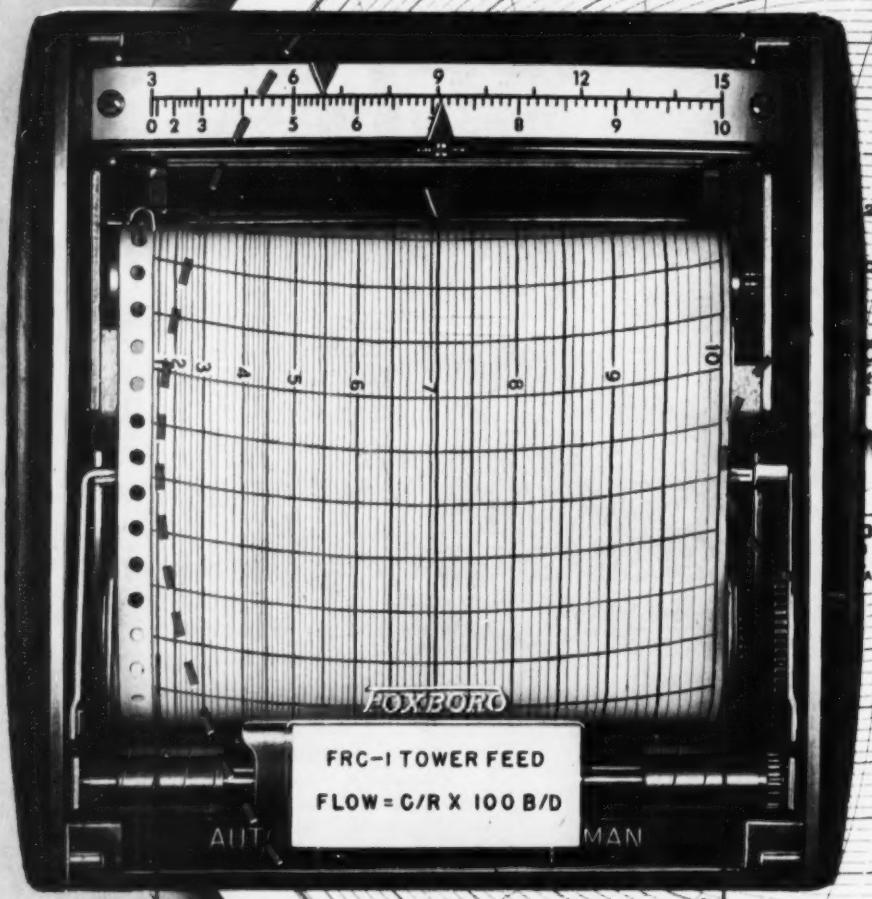
The New **CONSOTROL** M

The ONLY Graphic Panel Instrument wi



4 inches*

* Same scale length as 12" circular chart.

M/53 RECORDER

with FULL SCALE CHART!

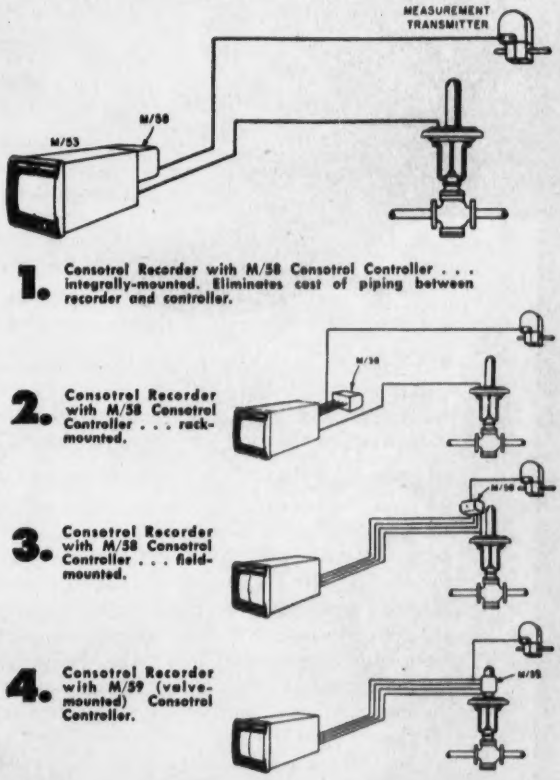
New in concept . . . new in principle . . . Foxboro's Consotrol M/53 Recorder combines amazing accuracy and convenience with extreme compactness . . . *and* you don't even sacrifice the accurate readability of full size charts. Full 4" wide, 30 day strip chart is same scale as 12" circular charts. What's more, the M/53 is by far the simplest to load, operate and maintain.

Single and 2-pen models, with or without control features, are available. Note some of the typical advantages:

- **Exclusive Valve-Position Indicator** — the only instrument of its type with *continuous* indication of valve direction . . . no switching required.
- **Exclusive Vertical Chart Operation** — will not run off spools . . . 5 hrs. of chart record showing at all times . . . chart loads quicker, easier than a box camera.
- **Single-Switch Automatic-Manual Transfer** — simple one-two operation. Instantaneous and bumpless.
- **No Knobs to turn** — all settings lever-operated . . . quick, precise operation . . . micrometer set-point drive, no backlash.
- **Positive Control Point** — cannot drift. Maintained by precision pressure transmitter.

Write for Bulletin 463 which contains full details on the M/53 and the complete Consotrol Line. **The Foxboro Company, 469 Neponset Ave., Foxboro, Mass.**

PROVIDES 4 BETTER RECORDING-CONTROLLING SYSTEMS



1. Consotrol Recorder with M/58 Consotrol Controller . . . integrally-mounted. Eliminates cost of piping between recorder and controller.

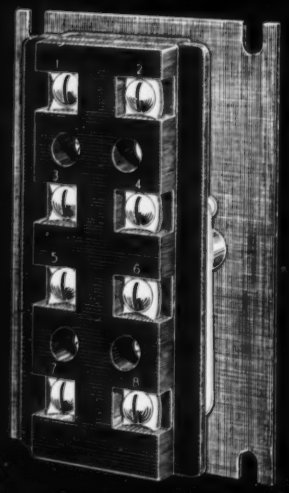
2. Consotrol Recorder with M/58 Consotrol Controller . . . rack-mounted.

3. Consotrol Recorder with M/58 Consotrol Controller . . . field-mounted.

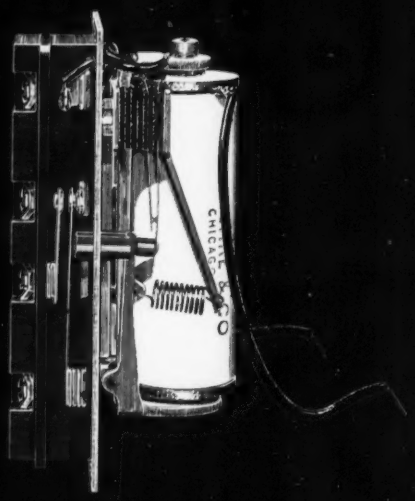
4. Consotrol Recorder with M/59 (valve-mounted) Consotrol Controller.

FOXBORO
REG. U. S. PAT. OFF.
INSTRUMENTS
Recording · Controlling · Indicating

Bring your relay problems to CLARE



Front View



Side View

CLARE Type "CP" POWER RELAY

● Some of the most important relay developments of the past decade have been the result of CLARE cooperation with engineering staffs of acknowledged leaders in the electrical and electronic industries.

Development of the CLARE Type CP Power Relay, for instance, came about from a consultation with a large electrical manufacturer who uses power relays extensively in the manufacture of various electronic control units. This CLARE customer objected to the use of ordinary power relays in plate circuit applications because one watt or more was required to operate them. Also, this necessitated the use of a high-current thyratron tube, or the interposition of another, more sensitive relay. He wanted a power relay sensitive enough to operate in the plate circuit of any triode, including miniatures.

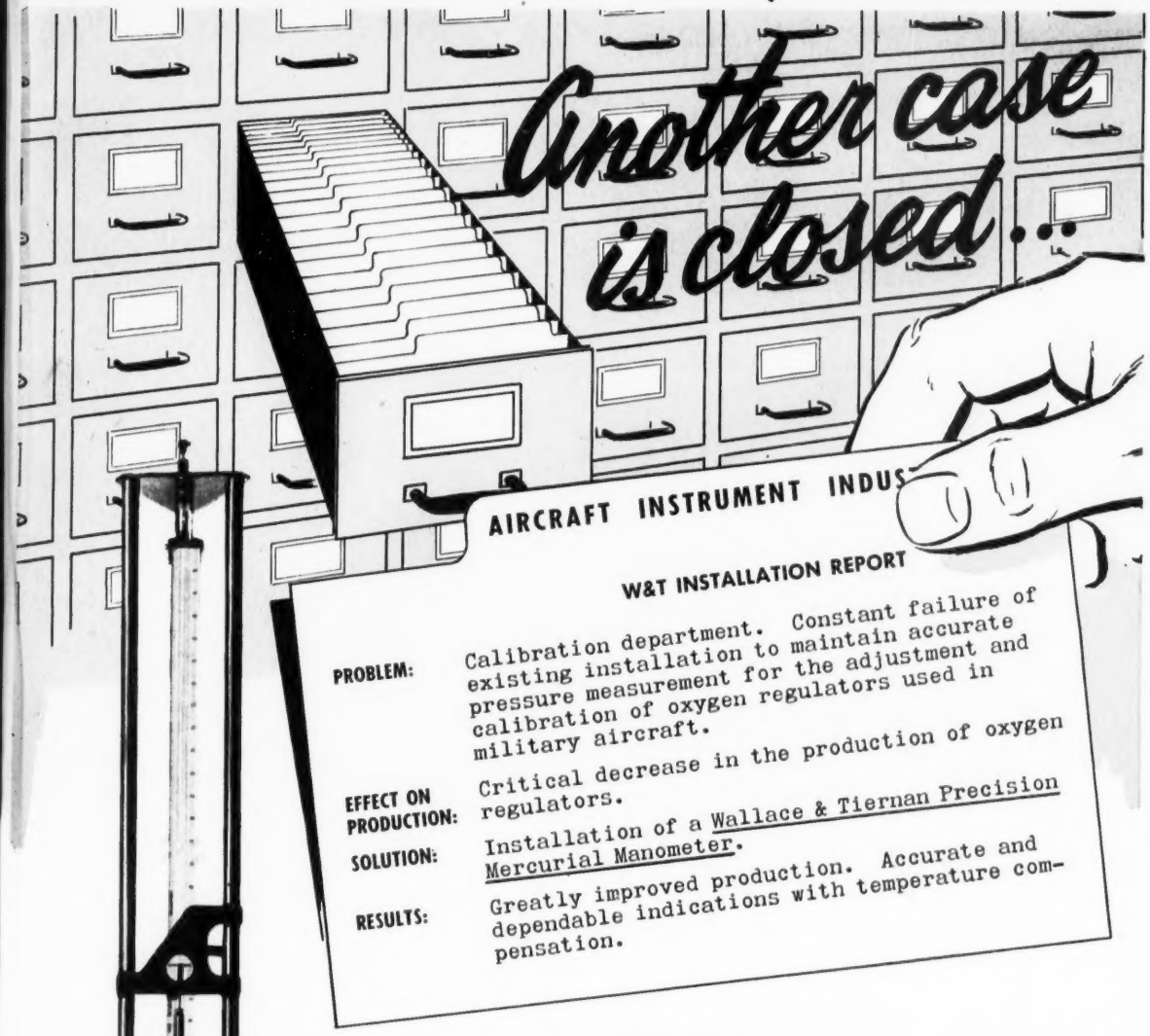
Years of satisfactory service from CLARE telephone-type relays had convinced the customer's engineers that the best way to achieve this would be to adapt these sensitive, dependable, durable relays to suit the special requirements of their use as power relays. Valuable contributions to the design of the CLARE Type CP Power Relay were made by the customer's engineers.

The result of this cooperation between these engineers and the CLARE engineering staff is a relay which simplified control equipment, saves money and space, and will outwear several ordinary power relays.

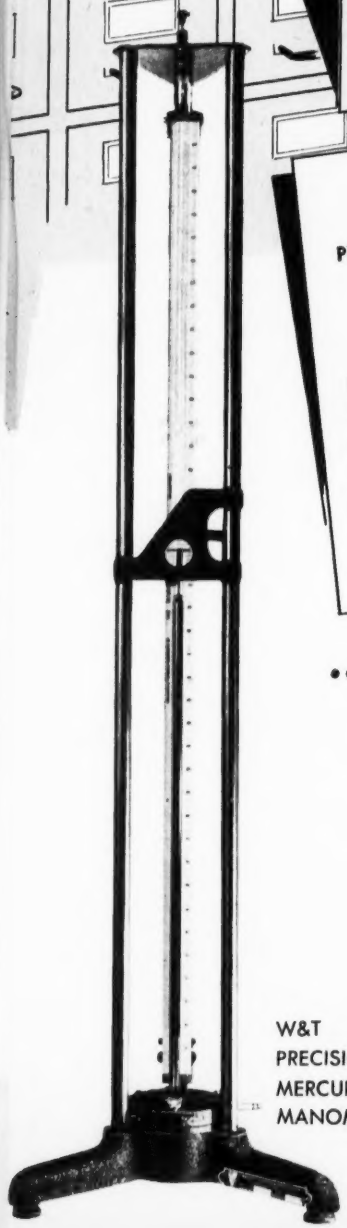
CLARE engineers, both in the field and in the plant, are anxious and willing to cooperate with you and your engineers to solve perplexing relay problems. Call the nearest CLARE office or write: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address: CLARELAY.

CLARE RELAYS

First in the Industrial Field


Another case is closed...
AIRCRAFT INSTRUMENT INDUS
W&T INSTALLATION REPORT
PROBLEM: Calibration department. Constant failure of existing installation to maintain accurate pressure measurement for the adjustment and calibration of oxygen regulators used in military aircraft.
EFFECT ON PRODUCTION: Critical decrease in the production of oxygen regulators.
SOLUTION: Installation of a Wallace & Tiernan Precision Mercurial Manometer.
RESULTS: Greatly improved production. Accurate and dependable indications with temperature compensation.

...Thanks to a W&T Precision Instrument



W&T PRECISION MERCURIAL MANOMETER

FEATURES:

- Scales are made with a precision dividing machine
- Precision bore tubing provides accuracy with interchangeability
- Float type indicator eliminates difficulty in reading meniscus
- Mercury-sealed valve permits evacuating the tube easily and quickly

If you have a problem in the measurement or control of pressure, write today for additional information.

WALLACE & TIERNAN
PRODUCTS, INC.

ELECTRICAL MECHANISMS AND PRECISION INSTRUMENTS

Belleville 9, New Jersey • Represented in Principal Cities
In Canada, Wallace & Tiernan Products, Ltd. — Toronto

A-92

The most *Comprehensive* line of dependable PANEL INSTRUMENTS

There are no blanks in the WESTON line of panel instruments. It includes all the sizes . . . all the types, ranges, sensitivities, too. Many specials, as well; developed to meet unusual requirements. All are built in the finest WESTON tradition for sustained accuracy over years of dependable service. Your local WESTON representative will gladly cooperate on any panel instrument problem, or write direct to . . . WESTON Electrical Instrument Corporation, 617 Frelinghuysen Avenue, Newark 5, New Jersey . . . *manufacturers of Weston and Tag instruments.*

WESTON 797 **PANEL** *Instruments*

Engineered Air Regulation

EVER SEE A JEWEL WITH NINE FACETS?

KENDALL MODEL 30

The little air regulator with big regulator capacity and performance

1 SMALL SIZE . . .
Only 1-11 16" x 2-1 4" x 4-1 2" high, including adjusting knob.

2 HIGH CAPACITY . . .
Up to 35 CFM free air with 90 psig supply pressure.

3 BALANCED DESIGN . . .
Accomplished by Kendall's unique deep convolution compensating diaphragm.

4 INHERENT STABILITY . . .
Engineered in the design by isolating the stabilizing chamber.

5 FLOW COMPENSATION . . .
Rising characteristic with increasing flow by venturi tube boost.

6 UNIT CONSTRUCTION . . .
Cleaning and inspection made easy by unit inner valve assembly.

7 PRECISION WORKMANSHIP . . .
Featured in all Kendall Regulators.

8 FLEXIBLE MOUNTING . . .
Pipe – Panel – Bottom – Side.

9 PERFORMANCE . . .
- Can be set to 1 4" water.
- 25 psi variation in upstream will result in less than 0.05 psi change in downstream pressure on dead end service.

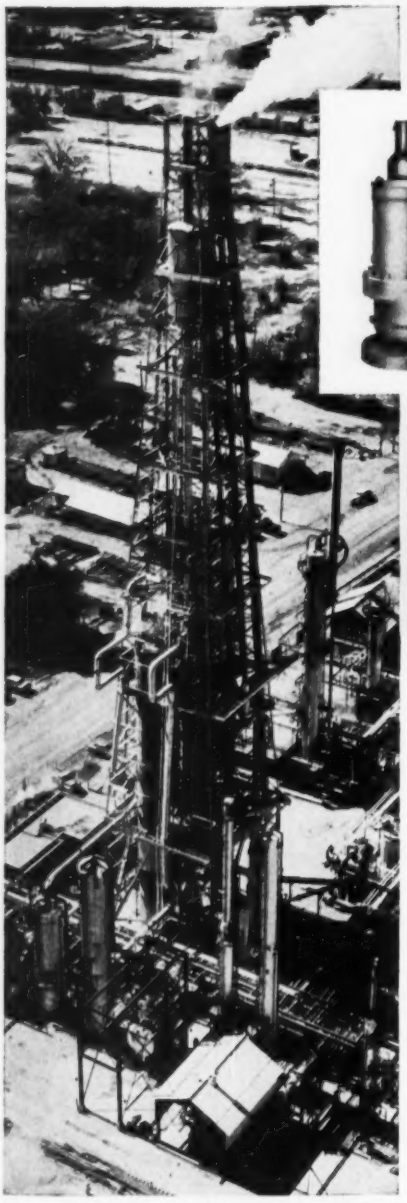
STOCK RANGES
0-10 psig
0-30
0-60
0-100

LINE SIZE
¼" or ⅜" N. P. T.

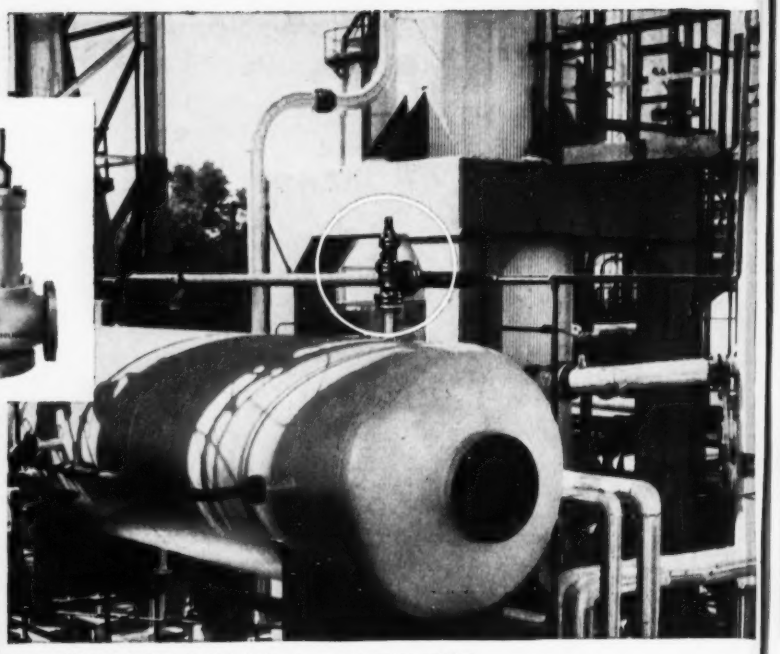
GAUGE TAPS
⅛" N. P. T.

BULLETIN 9523 describes it
BULLETIN 4521 describes its full size companion
BULLETIN 4522 describes its companion air volume booster

KENDALL CONTROLS CORPORATION
144 MOODY STREET WALTHAM 54, MASS.



Packaged TCC Unit, engineered and erected by Southwestern Engineering Company in cooperation with Socony-Vacuum Oil Company, Inc., licensor of the TCC process. It provides highly efficient production facilities for the independent refiner with up to 12,000 barrels per stream day crude oil capacity.



Consolidated Safety Relief Valve on wash water settler —one of the 42 installed on the TCC Unit.

WORLD'S FIRST PACKAGED TCC UNIT

Protected

BY 42 CONSOLIDATED

SAFETY RELIEF VALVES

A few months ago, the first packaged Thermofor Catalytic Cracking Unit went on stream at the New Mexico Asphalt & Refining Company, Artesia, New Mexico.

To protect the new facilities against overpressures, Consolidated Safety Relief Valves are used throughout the TCC feed preparation unit, catalytic section, gas recovery and catalytic polymerization plants.

Consolidated Safety Relief Valves were chosen for their absolute dependability. Outside bevel seat and floating guide construction eliminate leakage under discharge piping stresses. The disc moves on a radial seating surface—complete tightness is assured in all positions within the deflection range, under all service conditions. 25% fewer parts simplify servicing, minimize standardization problems, reduce maintenance costs. Continuous performance is certain at the rated capacity.

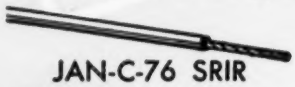
The packaged TCC Unit meets the nation's urgent need for increased gasoline yield and improved anti-knock ratings. The installation of Consolidated Safety Relief Valves safeguard life, property and continuous production. Your local distributor will gladly tell you all about them.

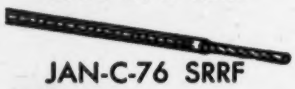
CONSOLIDATED SAFETY RELIEF VALVES

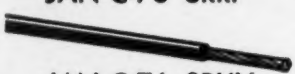
A product of **MANNING, MAXWELL & MOORE, INC.** TULSA, OKLAHOMA

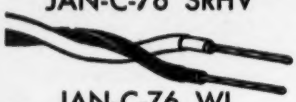
MAKERS OF 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'HANCOCK' VALVES, 'ASHCROFT' GAUGES. BUILDERS OF "SHAW-BOX" CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.

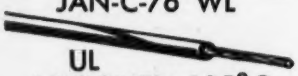
Tested and approved
—FOR SAFETY AND DEPENDABILITY BEYOND SPECIFICATION

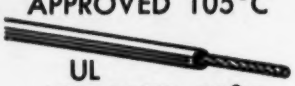

JAN-C-76 SRIR


JAN-C-76 SRRF


JAN-C-76 SRHV


JAN-C-76 WL


UL APPROVED 105°C


UL APPROVED 90°C

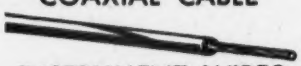
UL APPROVED 80°C

FLEXIBLE CORD

TV LEAD-IN WIRES

SHIELDED WIRES & CABLES

COAXIAL CABLE


INSTRUMENT WIRES

COMMUNICATION WIRES & CABLES

SPECIAL WIRES & CABLES TO SPECIFICATION

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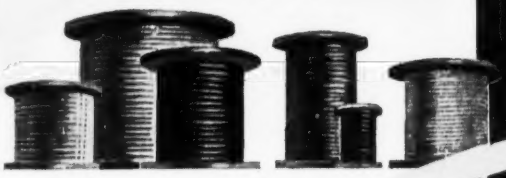
WIRES and CABLES



JAN-C-76 WIRES
80°–90°–105°C HOOK-UP WIRE
SHIELDED WIRE AND CABLE
FLEXIBLE CORDS
COAXIAL CABLE
TELEVISION LEAD IN CABLE
GAS TUBE HIGH TENSION CABLE
OIL BURNER IGNITION CABLE
BLASTING WIRE
THERMOSTAT CABLE
BELL AND OFFICE WIRE
TW BUILDING AND FIXTURE WIRE

CHESTER makes them all!

All Chester wire and cable features the extra dependability, long service life and easier working qualities of plastic insulation. Their tough, impervious plastic coats provide maximum immunity to abrasion, weather, oil and most chemicals. They are smooth, pull through conduit with minimum effort and present a fine appearance in exposed locations.

There's a Chester single or multi-conductor wire or cable for practically every indoor or outdoor requirement including many special constructions for the electrical, electronic, TV, radio, telephone and other industries. Why not write today for full information?

"Chesty" says—

Write today for your free copy of the Chester Wire and Cable catalog. A complete guide to plastic covered wire and cable for every electronic and electrical application. Please address inquiries on company letterhead.

CHESTER CABLE CORP.
CHESTER, NEW YORK

MANUFACTURERS OF QUALITY WIRE AND CABLE FOR EVERY ELECTRICAL AND ELECTRONIC REQUIREMENT

through one-piece bonnet construction

The rugged, jointless, steel bonnet of the Honeywell Series 700 Valve affords greater strength, simpler disassembly for inspection and maintenance . . . has deep, integral stuffing box built to superior performance standards, top-and-bottom packed lantern gland to minimize leakage. The Honeywell Series 700 wide band proportioning valve comes in a full range of styles and sizes . . . has *all* the features you look for in a fine valve. Write today for your copy of Bulletin 700-3.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division,* 1908 Windrim Ave., Philadelphia 44, Pa.

MINNEAPOLIS
Honeywell
VALVE PRODUCTS

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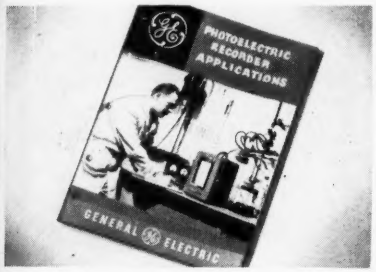
First in Controls

INSTRUMENTS FOR LABORATORIES



New Application Book Describes Use of Photoelectric Recorder

General Electric's new bulletin, "12 Applications of the Type CE Photoelectric Recorder," is just off the press. This publication describes new and unusual applications for which this versatile recorder has been found ideally suited. These stories, in addition to pointing out how industry is benefiting from the many unique qualities of the photoelectric recorder, will also suggest how the instrument can be utilized to solve other new measuring and recording problems.

HIGH-SPEED RESPONSE

The CE recorder is designed for recording rapidly changing phenomena with a minimum burden on the measured circuit and is available with a sensitivity as low as 1 microampere full scale. Response periods can be as fast as 1/5 second for full-scale deflection. Chart speeds range from ½-inch per hour to 72 inches per minute. Prices start at $698.88* for complete equipment. Check coupon below for your copy of new bulletin GEA-5536, which describes uses of photoelectric recorder.

*Mfgs. suggested retail price.

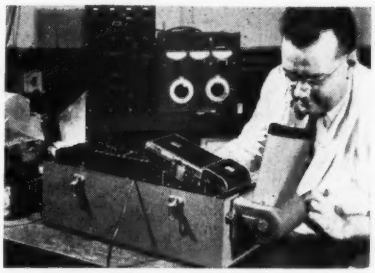
1952 CATALOG

G-E Measuring Equipment

80 pages describing all of General Electric's testing and measuring devices. For free copy check GEC-1016 in coupon at right.

Three New Accessories Announced for G-E Low Cost Portable Oscillograph

Just announced are three new accessories for the G-E Type PM-18 portable oscillograph. The PM-18 is designed for industrials and schools who require a low-cost instrument which will record two, three, or four rapidly or slowly changing currents and voltages simultaneously.



CONTINUOUS-DRIVE FILM HOLDER

The new accessories include a continuous-drive film holder for those applications which require an extra long record; a viewing attachment for observing the wave form before taking a record; and a new high-sensitivity galvanometer with a rating of 1.67 millimeters per microampere at one meter.

A new sweep mirror is also incorporated which provides adjustable time sweep of 0.1 to 0.5 second in addition to the original non-adjustable 1/60-second sweep.

The PM-18 with Polaroid-Land film holder and 2 galvanometers cost only $773.76*. Check coupon for bulletin.

Eastern Lab Saves Time In Making Resistance Measurements With G-E Portable Double Bridge

A large eastern laboratory reports that they are able to save time and obtain greater accuracy in making resistance measurements by using the G-E portable double bridge.

Designed for simple and quick measurements by a single operator, the bridge has only one dial to adjust, has a self-contained power supply and may be easily transported.

For maximum utility, this precision instrument has 8 ranges permitting measurements from 0.0001 to 22 ohms at an accuracy of 0.1 per cent of full scale, e.g. 0.000001 ohms at the lowest range. Price is $304.20*. Check coupon below for more information.

SECTION B605-21, GENERAL ELECTRIC
SCHENECTADY 5, N. Y.

Please send me the following bulletins:
Indicate:
√ for reference only
× for planning an immediate project

- ☐ Photoelectric Recorder GEA-5536
- ☐ Portable Double Bridge GEC-251
- ☐ Type PM-18 Oscillograph GEC-580
- ☐ 1952 Catalog GEC-1016

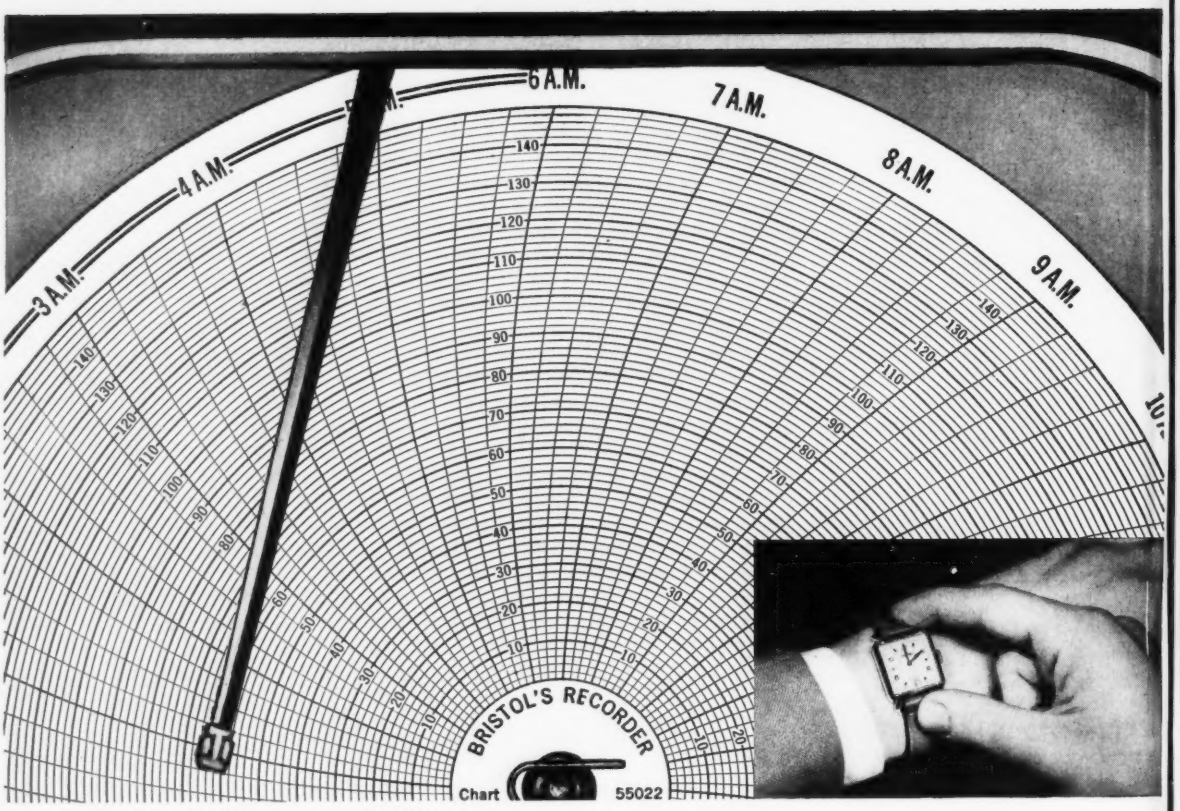
NAME.....

COMPANY.....

STREET.....

CITY.....ZONE.....STATE.....

GENERAL ELECTRIC



No watch can be more accurate than its dial...

No recorder can be more accurate than its chart!

For accuracy's sake, insist on Bristol charts for your Bristol recorders.

The chart is the scale that marks the recorder's measurements. Since only Bristol knows what those measurements are, only Bristol can make charts to record them accurately.

Bristol charts *do not* contain fillers, which cause poor inking, pen failure.

If you use a sizable quantity of Bristol charts a year, ask about our Chart Purchase Plan for savings up to 50%. Address The Bristol Company, Chart Division, 113 Bristol Road, Waterbury 20, Conn.

BRISTOL

The dependable Guidepost of Industry

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

The Superior Tube That Speeds Up The Race

Furnishing tubing that speeds a customer's production processes is a Superior specialty.

A case in point is illustrated above. The customer, New Hampshire Ball Bearings, Inc., manufactures high-speed, precision ball bearings. They formerly machined the races for certain of their smaller sized bearings from solid stock. This represented a considerable material loss . . . and a substantial time loss in the manufacturing process.

Prime requirements for the races were concentricity within 10% of the race wall thickness, dimensional tolerances under .002" and hardness. After consultation with us the customer began to fabricate these races from 52100 Alloy Steel tubing. Time, material and money were saved and the product improved.

Such savings are almost a commonplace with Superior customers. Because of our long experience in standard production of what is generally regarded as specialty tubing, we can frequently supply a quick and easy solution to the most difficult problems . . . and generally do so without charging "premium" or special handling prices.

If you have a need for fine small tubing in any analyses . . . almost any shape . . . and of a superior quality . . . it will pay you to check with us. We may be able to fill your needs from stocks of our selected distributors in key cities. Write Superior Tube Company, 1968 Germantown Ave., Norristown, Penna.

BE SURE ABOUT TUBING— SPECIFY

Superior

THE BIG NAME IN SMALL TUBING

All analyses .010" to ⅜" O.D.
Certain analyses (.035" max. wall) up to 1⅜" O.D.

ROUND AND SHAPED TUBING

Available in:

Carbon Steels:
A.I.S.I.—C-1008, MT-1010, MT-1015, C-1118, MT-1020, C-1025, C-1035, E-1095

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Stainless Steels:
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Nickel Alloys:
Nickel, "D Nickel"®, "L Nickel"®, "Monel"®, "K Monel"®, "Inconel"®, 30% Cupro Nickel.

Beryllium Copper

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. UNderhill 0-1331.

®Reg. U. S. Trademark International Nickel Company

R-S valvEvents

• EXCERPTS FROM THE R-S BOOK OF EXPERIENCE •

For Operating Ease in Inaccessible Locations

INSTALL R-S CHAINWHEEL VALVES

Few Chainwheel Turns. R-S Valves are completely closed from the fully open position by the movement of the valve vane through 77½° of arc. Operating ease is one of the chief advantages of R-S Valves.

Economy in First Cost. R-S narrow face-to-face design results in minimum number of working parts, less metal, less machining, lower weight and less supporting structure—hence economy in first cost.

Accurate Engineering. Body assemblies are accurately engineered mechanically and metallurgically. A. S. A. standards are equaled or exceeded in every detail.

Low Pressure Drop Saves Power. In the open position the streamlined vane causes a Venturi action. Pressure drop is therefore exceptionally low. Pumping costs are reduced accordingly.

More Control Rangeability. Power-controlled prime movers delivering 15 foot-pounds to 38,000 foot-pounds of torque open or close at any desired speed. Full closure requires one second to ten minutes depending on requirements and the type of material controlled. Positive shut-off is obtained with a rubber seat.

Self-cleaning. There are no pockets to house sediment, no change of flow direction to create turbulence or wire drawing and therefore less likelihood of erosion and cavitation.

Maintenance Practically Nil. Every R-S Valve is designed and constructed for rugged service and provided with safety factors to give complete satisfaction in the service for which it is designed. Packing trouble is not common to R-S Valves since the shaft moves only with an oscillating motion.

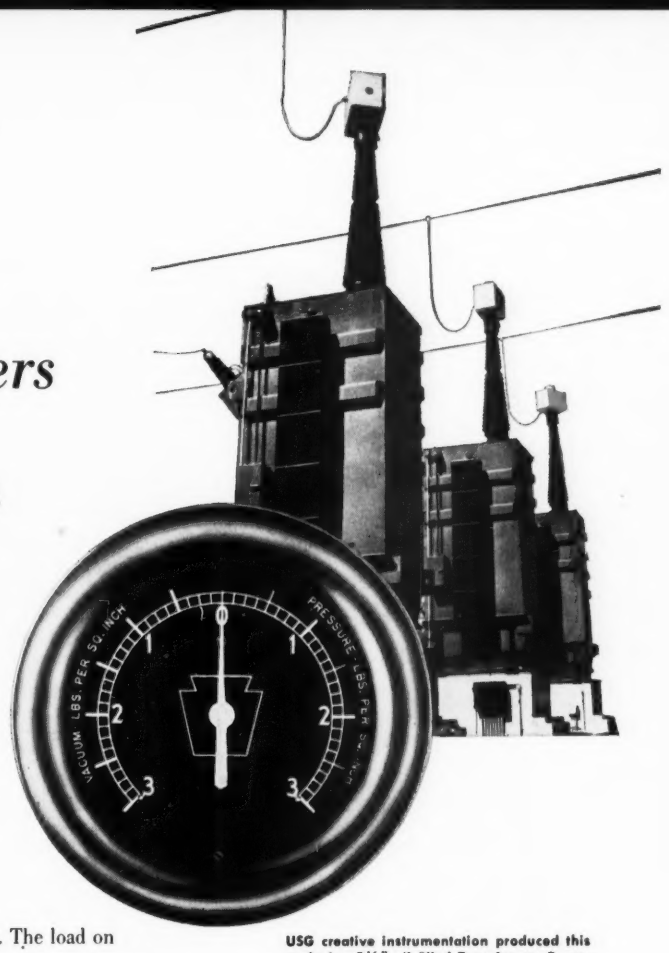
Consult your local R-S Valve Engineers, or write direct.

R-S PRODUCTS CORPORATION • 4600 Germantown Ave., Philadelphia 44, Pa.

An S. Morgan Smith Company Subsidiary

DISTRICT OFFICES IN PRINCIPAL CITIES

How to tell when transformers suffer from high or low blood pressure



Transformers are sensitive to temperature changes. The load on transformers of the inert-air or gas filled types increases or decreases with the ambient temperature. This could lead to trouble if no visual or aural danger signal were given.

US Gauge studied the need and came up with two solutions—two USG Transformer Gauges. One solution—the USG oil-filled transformer gauge, is so constructed that oil dampens vibration from the transformer making it possible to mount the gauge directly upon the transformer. Vibration which might cause an ordinary compound gauge to fail will not affect this instrument.

The other answer—the USG Transformer Compound Alarm Gauge is capable of being hooked up to any of the warning signals currently available. It provides unusually accurate indication and low switching differentials for a gauge with such low pressure limits.

If you are interested in the health of your transformer, you will want us to forward full details on these Transformer Alarm Gauges. If, however, you are more interested in the way USG approaches an instrumentation problem—your problem—get in touch with United States Gauge, Division of American Machine and Metals, Inc., Sellersville, Pennsylvania, and let our Engineering and Production "know how" assist you.

USG creative instrumentation produced this exclusive 3½" oil-filled Transformer Gauge shown above. Oil dampens vibration, permits direct attachment of gauge to transformer. Case actually "breathes", eliminating "barometer effect".

You are looking at the USG 3½" Transformer Alarm Gauge. Note the easily-readable dial and connections for hooking in a signalling system. Separate diaphragms for operating pointer and switches eliminate friction errors.

Quality Gauges Engineered for Enduring Accuracy

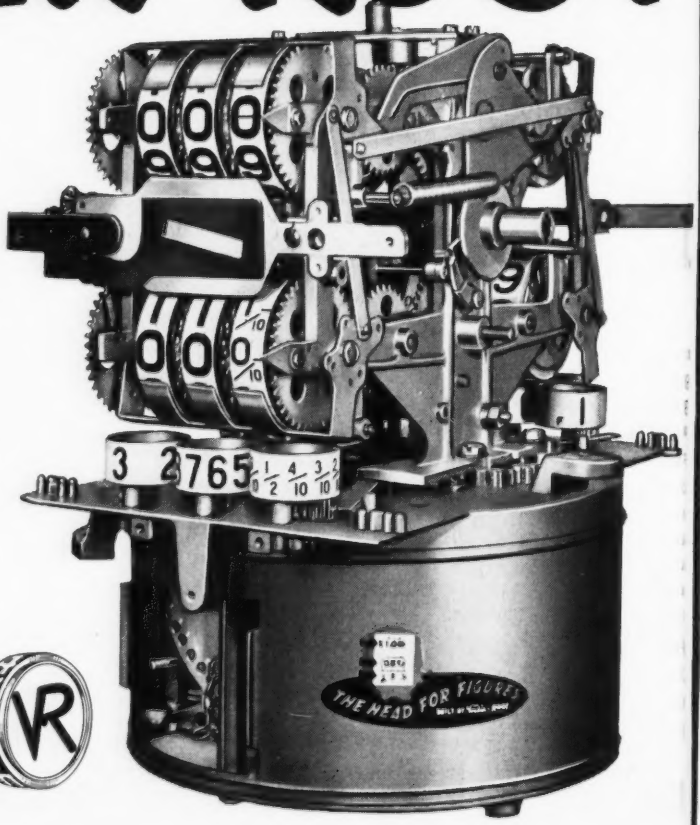
UNITED STATES GAUGE

PRODUCTS OF UNITED STATES GAUGE... Absolute Pressure Gauges • Aircraft Instruments • Air Volume Controls • Altitude Gauges • Boiler Gauges Chemical Gauges • Mercury, Gas, and Vapor Dial Thermometers • Glass Tube and Industrial Thermometers • Flow Meters • Inspectors' Test Gauges Precision Laboratory Test Gauges • Marine, Ship and Air-Brake Gauges • Voltmeters • Ammeters • Welding Gauges.
OTHER DIVISIONS OF AMERICAN MACHINE AND METALS, INC. AT SELLERSVILLE, PA.: GOTHAM INSTRUMENTS, AND AUTOBAR SYSTEMS

It Computes the Cost of Gasoline Pumped... in All of the World's Currencies

Everyone Can Count on VEEDER-ROOT

Yes, this Veeder-Root Gasoline Pump Computer speaks the languages of 144 countries! A rugged, accurate mechanism of 800-plus parts, it's the modern protection given you by gasoline pump manufacturers, gasoline refiners and their service-station outlets . . . *to make sure you get full measure in your tank, and the right change in your pocket* (or you can buy in "even money"). And what's more, it underscores the fact that "Veeder-Root Counts Everything on Earth" . . . electrically, mechanically or manually . . . with standard and special devices of every conceivable type. Do *you* have a counting problem, in any of your defense work or any of your regular production? If so, you can count on V-R to help you in every possible way.



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"The Name That Counts"
HARTFORD 2, CONNECTICUT
Chicago 6, Ill. • New York 19, N. Y. • Greenville, S. C.
Montreal 2, Canada • Dundee, Scotland
Offices and Agents in Principal Cities

"Counts Everything on Earth"

Actual size

Look behind this new Taylor Dial

and you will see a all-new movement design that gives greater accuracy, greater flexibility of adjustment, and greater convenience for temperature, pressure and load applications.

FOR TEMPERATURE, mercury actuation uses a new Bourdon spring that gives greater accuracy and sensitivity and 100% over-range protection, short range spans, and smaller bulbs for installation convenience. Available also with gas, organic liquid (Monolex) or vapor actuation to fit every temperature requirement within the limits of −100° to +1200° F.

FOR PRESSURE, there are range spans from 12 psi to 20,000 psi, Bourdon springs or C springs in a variety of metals to fit required services. Standard thin diapnragm volumetric pressure systems can also be used.

FOR LOAD, a new mercury Bourdon spring has been developed for highest accuracy with Taylor tension and compression load elements.

THE NEW CASE is made of die-cast aluminum, can be face or flush mounted, is fume and moisture proof. Special pointer permits easy, accurate zero settings. Take your choice of double-strength sheet glass, shatterproof glass or anti glare glass. Ask your Taylor Field Engineer, or write for **Bulletin 98214.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

▼ ▼ ▼

Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.

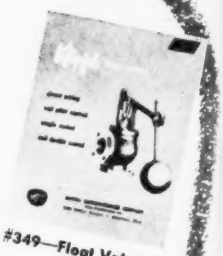
TAYLOR INSTRUMENTS MEAN ACCURACY FIRST

#148—Reducing Valves

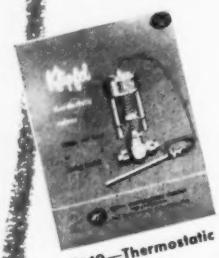
for temperature, pressure, liquid level control . . .

Choose Klipfel valves

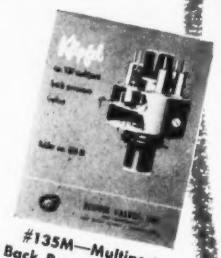
For dependability and economy . . . whether for plant equipment or manufactured products . . . specify Klipfel Valves . . . a wide range of standard types, as illustrated below, or controls designed specifically for you. If you have a control problem, discuss it with Klipfel Engineers. Write for the latest Klipfel Valve bulletins shown here; each contains valuable, easy-to-use selection and specifying data.



#349—Float Valves

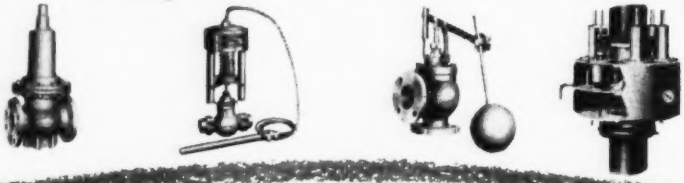


#449—Thermostatic Valves



#135M—Multiport Back Pressure Valves

Klipfel VALVES INCORPORATED
Hamilton, Ohio

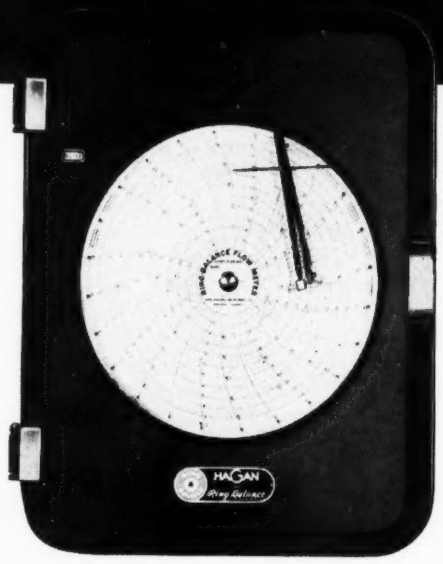


FINDS VACUUM-SYSTEM LEAKS WITHOUT SHUTTING DOWN

At Mrs. Tucker's Foods, Inc., Sherman, Texas, a G-E Type H Leak Detector is used to find minute leaks in the vacuum deodorizer. Operator pictured inserts G-E Leak Detector in exhaust pipe of vacuum system. Using portable cylinder of Freon, workman then goes over entire system. Leaks draw the Freon into the system and through the exhaust pipe, sounding auto horn alarm. Freon does not contaminate oil. For more information on the Type H Leak Detector, contact your nearest G-E Apparatus Sales Office or write General Electric Company, Section 687-106, Schenectady, N. Y.

GENERAL ELECTRIC

Here is an easy equation—
HAGAN Ring Balance Meters = Dependability



WITH Hagan Ring Balance Meters you get accurate flow integration on oxygen, water, steam, gas, oil or other fluids. You get a meter that is rugged and sturdy, but still a precision instrument throughout. Design is simple and maintenance costs are low.

HAGAN RING BALANCE FLOW METERS are the most versatile meters available. A single meter unit can indicate, record, and integrate one or two flow rates. Standard modifications provide for pressure and temperature compensation. Ring assemblies are available which are capable of measuring differentials from 1″ to 420″ water column maximum and for static pressures ranging up to 15,000 psig.

For more information on how dependable Hagan Ring Balance Flow Meters can answer your metering problems, clip the coupon, or write, wire or call Hagan Corporation, Hagan Building, Pittsburgh 30, Pennsylvania.

Features of every HAGAN Ring Balance Meter include:

- **Ease of dead weight calibration**
- **No stuffing boxes**
- **Adjustable, full scale range**
- **Mercury level not critical**
- **High sensitivity at low flow rates**

Clip this coupon for information

Hagan Corporation
Hagan Building
Pittsburgh 30, Pennsylvania

Please send me further information on Hagan Ring Balance Meters. I am particularly interested in .....

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HAGAN BUILDING, PITTSBURGH 30, PA.

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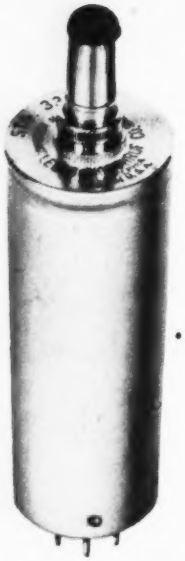
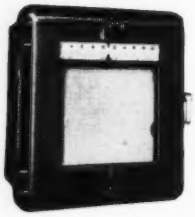
RING BALANCE FLOW AND PRESSURE INSTRUMENTS
METALLURGICAL FURNACE CONTROL SYSTEMS
CONTROL SYSTEMS FOR AERONAUTICAL
AND AUTOMOTIVE TESTING FACILITIES



A lot of engineering for a Component!

and every Speedomax user benefits by it!

Converter's job in Speedomax instruments is to receive the (often very small) direct current signal which is related to the temperature, stress pH or other condition being measured, and produce an alternating voltage. This output is amplified, and then directs the balancing system to measure, record, and if desired control.



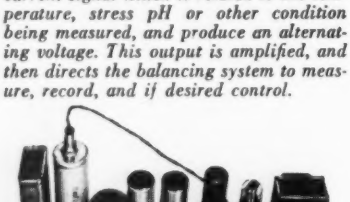
• The operating precision of the thousands of Speedomax Recorders and Controllers which serve industry and science begins with the engineering of components like this Converter. Our specifications apply at all stages—all the way back to the plants which make metals, insulation materials, etc., for us. These specs represent also the best thinking of our suppliers' engineers. The resulting materials are thus quality-controlled for us—and us alone.

From these materials our engineers tell our factory how to make converter parts to truly tight specifications. Some parts require principally flatness, or elasticity, or dimensional stability. Reeds need correct natural frequency. Many parts of course combine various needs; each gets its requirements.

Life tests show Fidelity and Stamina. Ingenious and often original design creates from these parts a converter with noise level equivalent to only 0.2 microvolt in an emf potentiometer circuit. And this fidelity promotes accurate measurement and control.

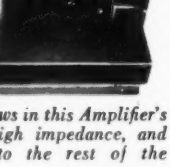
Running on life tests since 1948, present-model converters are today still well inside performance tolerances. Such a run equals 21.9 years of 8-hours-a-day, 200-days-a-year-service—or 1.9 years more than the present age of the first Speedomax.

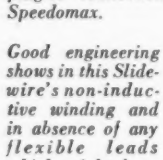
This kind of engineered performance is also built into the amplifier, slidewire, motor and scores of other exclusively Speedomax parts. It's at your service whether you want to control temperature of steel billets, or record the laboratory studies of steel molecules. Call on L&N application engineers in selecting the exact range (from among thousands) and the exact measuring circuit (from among 2300) to meet your needs. Write our nearest office, or 4955 Stenton Avenue, Philadelphia 44, Pa.



Good engineering shows in this Amplifier's thorough filtering, high impedance, and plug-in connection to the rest of the Speedomax.

Good engineering shows in this Slidewire's non-inductive winding and in absence of any flexible leads which might form inductive loops.





Good engineering shows in this balancing motor's small size, and in its torque ample to operate accessory control and signalling fitments.

CAREER OPPORTUNITIES AT L&N

Expansion program of this long-established firm has many features to attract outstanding recent graduates in engineering and science. Opportunities are in sales field engineering, product and application engineering, research, advertising, market development. Widely-respected policies assure recognition of progress and achievement. Address Personnel Manager for preliminary interview at nearest of 17 L&N offices.

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EDITORIAL By M. F. BEHAR

THE AUTOMATIC FACTORY—

100% Automatic Inspection . . . Plus Automatic Corrective Action

CLOSE approximations to the "manless" plant are *continuous-processing* plants in which the most critical steps are those in which *liquids and gases* are processed. None is a "factory" in the usual meaning of a plant where solid raw materials are cast, stamped, machined and otherwise fabricated into parts which, in turn, are assembled into finished products such as appliances and automobiles, beds and bicycles, cameras and clocks, and so on to zippers.

Visitors to even the most modern refineries observe manual labor being done on the loading docks. The criteria for defining a "plant" and a "factory" have much to do with calling a particular plant or factory "manless" or "automatic." To technical men, commonsense says that one fully-instrumented refinery *proper* may be called a manless "plant," whereas one fully automatic screw machine may not be called a manless "factory."

But most non-technical people who have asked us to explain "manlessness" could not see this distinction. To some of them, one automatic screw machine or one can-filling machine IS a manless factory because it runs without human attention, whereas one modern refinery IS NOT a manless plant because trained men are on duty in its controlhouse. Some of them were so unkind as to quote against us our 1942 assertion that only when the control-house MEN are replaced by a "judgment-and-decision" type of automatic controller will the refinery be *truly* manless. But we have also proposed a new criterion for the "manlessness" of either a plant or factory, based on (1) the degree to which waste or spoilage (in any form) is minimized, and on (2) the degree to which this minimization of spoilage itself, is automatized.

Consider the simplicity of inspecting the products of continuous processes and the ease of speedily making corrections *before* a single gallon of the effluent has to be condemned. Then consider the complexity (and hence difficulty) of inspecting all the components of an assembly and testing the assembly in various ways, together with the difficulty of "feeding back" corrective information in time to prevent rejects or seconds. Thus, our criterion seems to favor continuous-process plants as against multiple-fabricating-operations factories; but it points the way to saving untold millions of man-hours per year in Defense and civilian-goods factories. Of course it will be difficult to make factories as manless as continuous-process plants! In some cases it may *seem* impossible.

What really is impossible is to make time run backward: no human or automatic inspector can order a change in last week's (or last hour's) production lot of Part S-35-J-91. But it's the same in continuous-process plants: no human operator or automatic controller can control what the pressures and flows and temperatures WERE last week or one minute ago!

Preventing rejects or seconds—or waste in any form—is essentially a matter of catching deviations before they become large. For continuous processes, the first step is to install adequately sensitive primary measuring elements: thermocouples, orifice plates, pH cells, etc. For machines which turn out parts one by one, the first step is to install primary measuring elements in the form of adequately sensitive (and otherwise suitable) automatic inspectors and classifiers: not only dimensional but those that test automatically for mechanical, electrical, and chemical properties or characteristics.

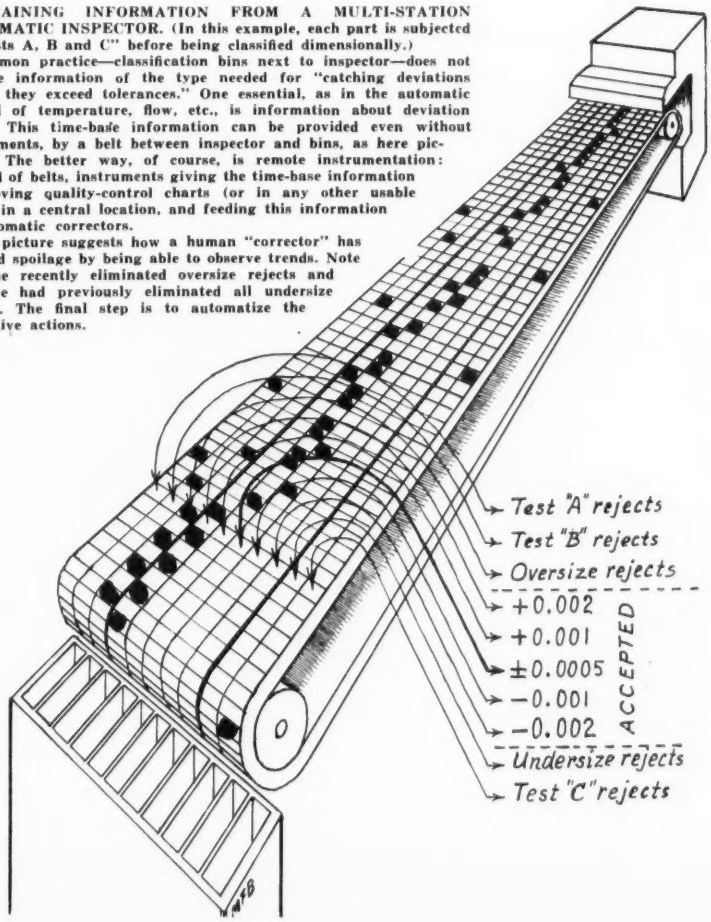
The second step is to *use* the information provided by the measuring elements—to use it quickly, *before* the deviations in the measured dimensions and properties become larger than the tolerances. With regard to this second step, we must confess that most Tool Engineers and Production Managers believe that it is too expensive. And as for the third and final step—automatically feeding back the corrections in time to prevent spoilage—that's where most production men dismiss us as an impractical visionary.

Difficult? Yes! Impossible, no!

OBTAINING INFORMATION FROM A MULTI-STATION AUTOMATIC INSPECTOR. (In this example, each part is subjected to "tests A, B and C" before being classified dimensionally.)

Common practice—classification bins next to inspector—does not provide information of the type needed for "catching deviations before they exceed tolerances." One essential, as in the automatic control of temperature, flow, etc., is information about deviation trend. This time-base information can be provided even without instruments, by a belt between inspector and bins, as here pictured. The better way, of course, is remote instrumentation: instead of belts, instruments giving the time-base information on moving quality-control charts (or in any other usable form) in a central location, and feeding this information to automatic correctors.

The picture suggests how a human "corrector" has reduced spoilage by being able to observe trends. Note that he recently eliminated oversize rejects and that he had previously eliminated all undersize rejects. The final step is to automatize the corrective actions.



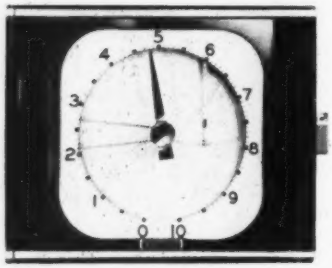
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, computing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 1315

Round-chart Recorders and Automatic Controllers

New 12-inch round-chart recorders and automatic controllers, added to maker's "Dynamaster" line, are high-speed continuous-balance null-type potentiometer and bridge instruments for indicating, recording and controlling variables that can be translated into direct current or emf. or capacitance or resistance. Usable primary elements include thermocouples, radiation detecting units, resistance thermometer

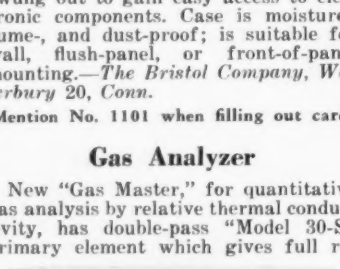


bulbs, pH amplifiers, tachometer magnetos, strain gages, smoke density detectors, thermal converters for power measurements, beta-ray gages, etc. Models are offered for full-scale pen travel in 7 seconds, 3 seconds, 1.5 seconds, or ⅔ second, with a wide variety of ranges. Controlling models are available with all types of pneumatic and electric control action. Unit universal construction permits complete interchangeability of components. Recording mechanism is on front of a hinged aluminum alloy panel which can be swung out to gain easy access to electronic components. Case is moisture-, fume-, and dust-proof; is suitable for wall, flush-panel, or front-of-panel mounting.—*The Bristol Company, Waterbury* 20, *Conn.*

Mention No. 1101 when filling out card.

Gas Analyzer

New "Gas Master," for quantitative gas analysis by relative thermal conductivity, has double-pass "Model 30-S" primary element which gives full response to most changes in gas quality in less than thirty seconds. Special construction of gas passages permits use of any non-corrosive cylinder gas or mixture as reference, facilitating oxygen and nitrogen purity studies, cylinder identification and observation of enriched oxygen and nitrogen atmospheres. Inert and special atmospheres may also be tested, as well as flue gas, respired air of humans or animals, and air:gas precombustion mixtures. Optional connections are provided for a recorder, also a calibrating resistor in galvanometer circuit for full-scale range adjustment. Dry cells supply current for portable operation; when unit is permanently installed, an external 6v.dc. source may be connected.—*The Gow-Mac Instrument Co., 22 Lawrence St., Newark* 5, *N. J.*



Mention No. 1102 when filling out card.

Temperature Controllers

New "Thermo Electronic" temperature controllers use resistance-bulb primary elements, are available in six temperature ranges between limits of minus 100 F. and 600 F.; have relays with load contacts for operating heating elements, electric valves, etc., and

signal contacts for red and green lights on instrument door. It is claimed that when temperature at resistance bulb deviates as little as 0.1 F. from set point, instrument takes immediate corrective action. Control action is continuous. Resistance bulbs have small volume and mass and solid contact between winding and housing. Measuring circuit is accurate within 0.25 percent of scale range. Variations in a-c. voltage or in resistance of bulb leads do not impair accuracy. Circuit is immune to electrical interference from induction heaters, spot welders, etc. Relay chatter is eliminated by lock-up circuits. Control relay is only moving part in instrument.—*Thermo Electric Co., Fair Lawn, N. J.*

Mention No. 1103 when filling out card.

Contact-making D-c. Indicator-Controller

New "Model 1087" contact-making instrument, of new core-magnet-mechanism type, has two stationary contacts (each independently adjustable over scale range by means of an insulated knob on front of instrument) and a contact carried on pointer. Contact circuit is electrically insulated from

moving-coil circuit and is subjected to a dielectric test of 500 volts a.c. between these circuits, as well as between all circuits and case. Contact rating is 6 volts 0.03 amps. d-c. noninductive, maximum. For automatic control, contact circuit can command small power relays, electronic relay systems, etc.—*Weston Electrical Instrument Corp., 617 Frelinghuysen Avenue, Newark* 5, *N. J.*

Mention No. 1104 when filling out card.

Mechanized Electroanalyzer

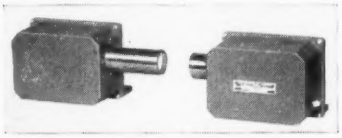
New "Electro-Analyzer," available in 2- and 4-spindle models, makes it possible to run separate (or duplicate) electroanalyses simultaneously. In both models, each spindle or station is equipped with its own independent components, permitting a complete flexi-

bility of schedule. Another feature is increased power facilities: 10 volts at 10 amperes, with a-c. ripple held to less than 2 percent. Rate of deposition being greatly affected by temperature of sample, new 200-watt thermostated "Sample-Heater" has been designed. A wide variety of accessories are available to "custom-tailor" new analyzer to specific laboratory needs. For example, many stirrer-electrode combinations are possible. New "Mercury Cathode Cell Kit" does away with time-consuming preanalysis separations by plating-out undesirable elements in a sample.—*Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.*

Mention No. 1105 when filling out card.

Photoelectric Control Units

New models of maker's source and photoelectric relay feature protection against light-source or tube-filament



failure, tube warm-up protection positive plate relay operation, positive-tube shields and rubber-based tube sockets.—*Autotron Co., Box 772-Q, Danville, Illinois.*

Mention No. 1106 when filling out card.

Electric-contact-making Traction Dynamometer

New "Model EL" traction dynamometer operates electrical warning signals, relays, motors, switches, etc.; is

available in 13 different capacities from 0-500 lbs. up to 0-100,000 lbs., with 5-in. or 10-in. diameter dial; is furnished with shackles and attachment pins; is rust- and moisture-proof.—*W. C. Dillon & Co., Inc., Forest Park, Illinois.*

Mention No. 1107 when filling out card.

Hygrometer for Sealed Packages

New "Hydrotector" measures effectiveness of sealed packages in preventing corrosion damage to their contents. Complete system consists of sensing element, portable indicator, mountings and tools. Humidity of sealed enclosure is measured by a small sensing element permanently installed inside package and connected electrically through a mounting to exterior of package. Portable indicator makes contact with mounting for reading. No special training is required. An individual package

20 MICROAMP METERS
WELCH D.C. PANEL METERS

dependable-
sensitive-
accuracy 2%
rugged-

Standard Equipment for many Radiation Devices, these Rugged, High Sensitivity Precision Instruments are the product of many years' experience in building Electrical Measuring Instruments.

MODEL NO. 350

- Alnico Magnets
- Sapphire Jewel Bearings
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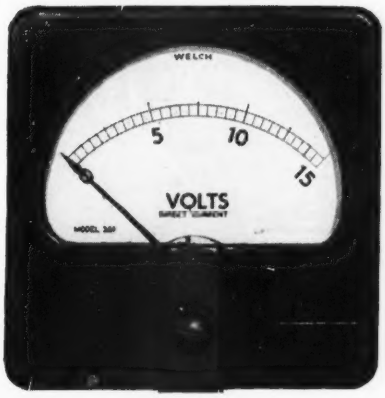
- Fume-proof Metal Scales
- Extremely Rigid Mounting
- Sensitive Movement
- High Torque Ratio
- Stable and Well-Damped
- Cases Moulded Bakelite for Flush Mounting



MODEL NO. 351

MODELS

350—3½ inch round—2.4 inch scale
351—3 inch square—2.4 inch scale
451—4½ inch rectangular—3.5 inch scale

TYPES

Microammeters 0-20 up to 0-500
Milliammeters 0-1 up to 0-500
Ammeters 0-1 up to 0-30
Voltmeters, various ranges, 100 to 50,000 ohms per volt
Zero Center Ammeters
DB Meters
Rectifier Instruments
Thermocouple Meters
Special Sealed Meters

Other Models and Ranges Available.

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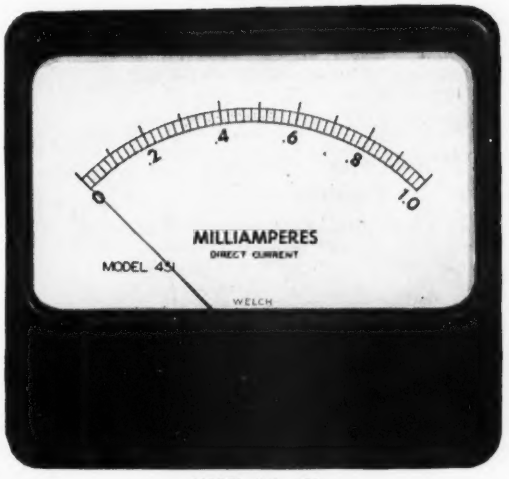
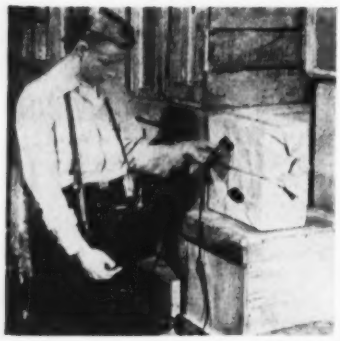


MODEL NO. 451

W. M. WELCH SCIENTIFIC COMPANY

1515 SEDGWICK STREET, DEPT. B — CHICAGO 10, ILLINOIS, U. S. A.

Manufacturers of Scientific Instruments and Laboratory Apparatus

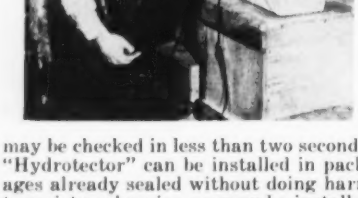


may be checked in less than two seconds. "Hydrotector" can be installed in packages already sealed without doing harm to moisture barrier, or may be installed in packages being prepared for storage. —*American Instrument Co., Inc., Silver Spring, Maryland.*

Mention No. 1108 when filling out card.

Vibration Pickup

New "Type 122" vibration pickup can be used in ambient temperatures as high as 500 F.; has no soldered joints



or connections. All wiring, insulation and materials are said to resist elevated temperatures. Pickup is claimed to have no practical lower limit on amplitude. Sensitivity 21 mv. per 0.001 in. double amplitude per 100 cps. Unit is convertible to horizontal and vertical operation. Usable frequency range 5 to 2000 cps.—*The MB Mfg. Co., Inc., New Haven, Conn.*

Mention No. 1109 when filling out card.

Differential Pressure Controller

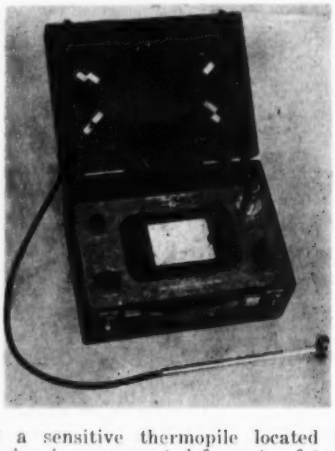
New "Type BB" operates a mercury switch from change in relationship of two pressure sources, such as upstream

and downstream pressures in case of a filter or orifice; can be furnished to function either from an increase or from a decrease in pressure difference. However, "Type BB" provides for reversing switch operation by interchanging pressure connections. Construction: Two matched chrome molybdenum Bourdon tubes operating one "Mercoid" magnet-actuated mercury switch. Ranges 60 to 2,500 psi.—*The Mercoid Corp., 4201 W. Belmont Ave., Chicago 41, Ill.*

Mention No. 1110 when filling out card.

Air-meter

New "Model H Air-Meter" operates on 90 to 135 v. ac., is accurate to 2 percent, measures velocities by means

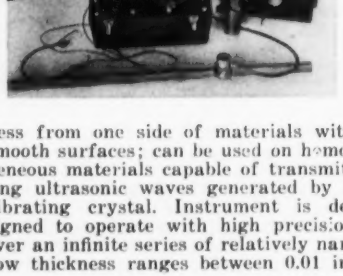


of a sensitive thermopile located in probe; is compensated for rate of temperature change; has dual velocity ranges (10-750 and 750-5500 fpm.) and an expanded low-range scale. Ease of operation: one switch turns on current and selects range; an adjustment of calibration knob compensates for line-voltage variations. "Model H" is adaptable to applications requiring permanent or remote installations. Any recorder operating on 10 mv. or less with a low current drain may be used with it.—*Hastings Instrument Co., Hampton 10, Virginia.*

Mention No. 1111 when filling out card.

High-precision Ultrasonic-principle Thickness Gage

New "Audigage Ultrasonic Micrometer" provides measurements consistently within 0.5 percent of actual thick-

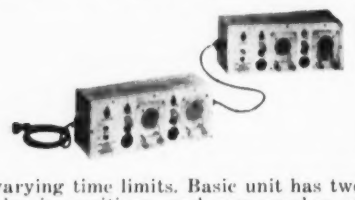


ness from one side of materials with smooth surfaces; can be used on homogeneous materials capable of transmitting ultrasonic waves generated by a vibrating crystal. Instrument is designed to operate with high precision over an infinite series of relatively narrow thickness ranges between 0.01 in. and 12 in. Plug-in frequency coils and matched dials for any desired frequency permit selection of frequency suited to required thickness-range. Since instrument accommodates two coils at once and each dial has provision for two scales, user has two thickness-ranges at his command at all times. Scales can be computed either for direct reading or to show deviations from any standard thickness desired. Instrument can be furnished for operation either on its own self-contained power supply or on 90-115v. 60-cycle power. —*Branson Instruments, Inc., 430 Fairfield Ave., Stamford, Conn.*

Mention No. 1112 when filling out card.

Automatic Time Controller

New "Add-A-Cycle Timer" provides a wide range of time cycles. Set-up time is minimized through use of plug-in adjustable timers, which are supplied in six overlapping ranges, from 1.5-12 seconds to 15-120 minutes. Thus it is possible to have adjacent cycles with widely



varying time limits. Basic unit has two plug-in positions, and any number of them may be cabled together and will cycle as a group, so that an unlimited number of time cycles may be obtained. Normal rating is 10 amps. 115 v.ac.; special ratings on request. For process timing "Add-A-Cycle" is custom built in wall-mounting cases with any required number of adjustable plug-in time cycles. Any cycle may be skipped without loss of time in event any part of process is temporarily out of use.—*Becker Equipment Co., 3020 N. Cicero Avenue, Chicago, Ill.*

Mention No. 1113 when filling out card.

Washing-machine Timer

New "Washing Machine Timer" is a plug-in portable model with decorative dial; automatically shuts off washing machine at end of selected

interval depending upon kind of materials put in machine; may stand or hang from wall: has a Telechron motor. —*The Tork Clock Co., Inc., Mount Vernon, N. Y.*

Mention No. 1114 when filling out card.

Digital Computer

New "Elecom 100" has a controlled memory capacity of 102,400 nine-digit "words"; can solve a 10-digit mathematical problem in 3 milliseconds; is said to be the first low-cost ($62,500) general-purpose electronic computer of its type to be mass-produced for general use by business and industry. It consists of three units: (1) conventional-type office desk at which operator sits, (2) metal drum memory unit, (3) computer proper which is housed in five steel cabinets joined together in a semi-circle. It operates on standard 120-v. ac. and can be easily moved about as units are mounted on casters.—*Electronic Computer Corp., 160 Avenue of the Americas, New York, N. Y.*

Mention No. 1115 when filling out card.

Digital-output Transmitters for Pressure, Flow, etc.

New models of "Digitrans" make possible indication or recording in digital numbers of mechanical displacement, pressure, acceleration, temperature, flow-rate, total flow, etc. Principle: frequency proportional to moving-member deflection is converted to a number by an electronic counter (supplied by user). Natural (center) frequency of a unit is preset at factory, may be from 2 to 40 kc.; variation of frequency for full-scale range (of pressure, flow, etc.) can be from plus-and-minus 2 percent to plus-and-minus 50 percent of center frequency. Therefore, resolution depends on chosen center-frequency and on required frequency shift; and accuracy depends on number of readings or records taken per minute or per second. Attainable resolution could be one part in 30,000. Most units have intrinsic accuracy of 0.1 percent of full-scale; some units have temperature control to minimize temperature error. Output of a unit can be read directly by operator; or can be transferred to magnetic tape or to recording or printing instruments; or can be stored in IBM or Remington-Rand punched cards.—*Wright Engineering Co., 180 E. California St., Pasadena, Calif.*

Mention No. 1116 when filling out card.

Stopclock

New "Durachron" spring-driven 4-in.-dial stopclock is claimed to be superior to conventional stopwatches because (1) it frees both hands and (2) it is more rugged and durable than stopwatches. It is capable of three different

DEPENDABLE
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WHEN YOU CAN'T AFFORD TO MISS
IN MEASURING:
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8 MEGACYCLE COUNTER-CHRONOGRAPH
DIVIDES 1 SECOND INTO 8,000,000 PARTS
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The use of an 8 megacycle crystal time base provides the highest resolution of time measurement available in direct reading instruments.
COMPLETE DEPENDABILITY
To assure the highest degree of dependability, a straightforward 3-stage binary counter is used at the 8 megacycle frequency, permitting the conservative use of decade counters at the lower frequencies.
DIRECT READING
Digital registration is used to indicate time from 1 microsecond to 1 second by means of 6 Potter decades. Fractional parts of a microsecond are read from a 3-stage binary counter which indicates in steps of ⅛ microsecond.
PROVED PERFORMANCE
Ten years of service in proving grounds and research centers give conclusive evidence that the simplified circuitry inherent in the Potter Counter-Chronographs provides the maximum reliability for critical timing applications.
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There is a Potter Counter-Chronograph made for your specific application. . . . High-speed digital recorders are available for permanent recording of measurements at rates up to 150 per second.
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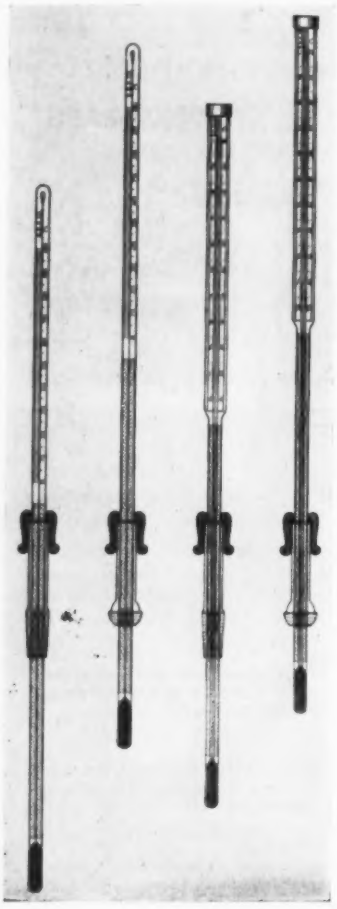
methods of operation: (1) Straight timing; (2) Timing action which is interrupted during observation; (3) Snap-back timing in which elapsed time is read while sweep hand is in motion and hand is returned to zero simultaneously to start another reading. Cost is said to be "less than an ordinary stopwatch."—*Andrew Technical Service, 3805 N. Clark St., Chicago 13, Ill.*

Mention No. 1117 when filling out card.

Adjustable-stem Thermometer

New "Adjustatherm" adjustable-stem thermometer is available in 6.5 in. and 11.5-in. stem lengths and in three



ranges: 0-150, 0-250 and 0-360 C. It is claimed that a set of two "Adjustatherms" will replace up to nine conventional type thermometers and permit obtaining both liquid and vapor temperature without dismantling equipment.—*Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.*

Mention No. 1118 when filling out card.

Service Man's Thermometer

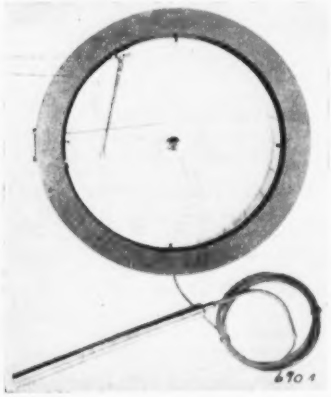
New model of "Serviceman Thermometer," for use in testing refrigeration equipment, etc., has internal mechanism completely reengineered: Bourdon-tube connections are fitted into female end-

pieces and silver-brazed to form leak-proof joints; internal stop protects against excessive temperatures; geared movement is of wear-resisting brass; "Recalibrator" has been shifted to back of reel-plate where it is easily accessible (no need to remove retaining ring and glass). New range is minus 40 to plus 65 F.—*Marsh Instrument Co., Skokie, Illinois.*

Mention No. 1119 when filling out card.

Sub-zero Thermometers for Industrial Processes

New distant-reading recording and dial-indicating thermometers for temperatures as low as minus 200 F. have been added to maker's line. "Model NR Sub-Zero Recording Thermometer" has



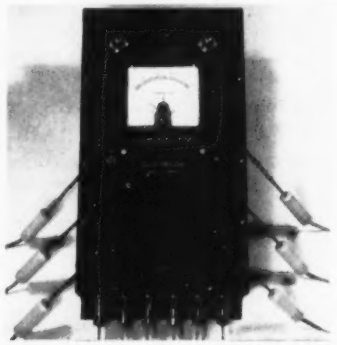
12-inch chart driven by a synchronous electric clock movement (spring clocks available on special order); weighs 10 lbs.; can be mounted on any vertical surface; is connected to cold chamber by an 8-foot stainless steel armored tube (longer if necessary); bulb is

0.75-in. brass 11 in. long. "Model PD Sub-Zero Dial Indicating Thermometer" is available in 6-in. and 8-in. sizes. Both instruments are available in several scale ranges between limits of minus 200 F. and 200 F.—*The Dickson Co., 7420 So. Woodlawn Ave., Chicago 19, Ill.*

Mention No. 1120 when filling out card.

Temperature Controller for Meat Smoking

New "Cook-Meater" is an indicating and signalling automatic temperature controller designed for meat-smoking,



wiener-curing, bacon-finishing, etc. Primary thermal elements are in 0.187-in. stainless-steel probes 6 in. long with 3-in. nylon handles and 50-ft. cables (up to 1000 ft. if specified). Standard range is 100-200 F., permitting 1-deg. accuracy. Instrument can be supplied with an automatic timer; also with device to rotate selector switch to a different probe every (approx.) 18 seconds.—*Swieco, Inc., 1512 E. Lancaster, Fort Worth 3, Texas.*

Mention No. 1121 when filling out card.

Data-recording M-p. Camera

New "Model 1013" data-recording camera is a 35-mm. motion-picture type (developed from North American Aviation Corp. basic design) for photographically recording instrumental results. Among features: constant exposure rate of 1/50th second regardless of frame speed; remote selection of automatic 4, 8 and 16 frames per second; any frame rate less than 5 per second may be pulsed manually or by external intervalometer; interchangeable Mitchell magazines; Bausch & Lomb 25-

nm. f2.3 coated Baltar lens (or equivalent) is standard equipment and other types are adaptable. Camera is suitable for photographing not only flight test instrumentation but industrial and research laboratory readings. It will operate under severe operational conditions: in temperatures from minus 60 F. to plus 160 F.; at accelerations through 9 g's; at altitudes to 60,000 feet. Power requirements are 28 volts d.c. or 110 volts a.c. optional.—*Aremac Associates, 329 W. Washington St., Pasadena, Calif.*

Mention No. 1122 when filling out card.

Automatic Spoken-warning Safety System

New "Message Repeater" is designed to promote safety in industrial operations. For example, in garages, messages such as "Don't smoke near gas-

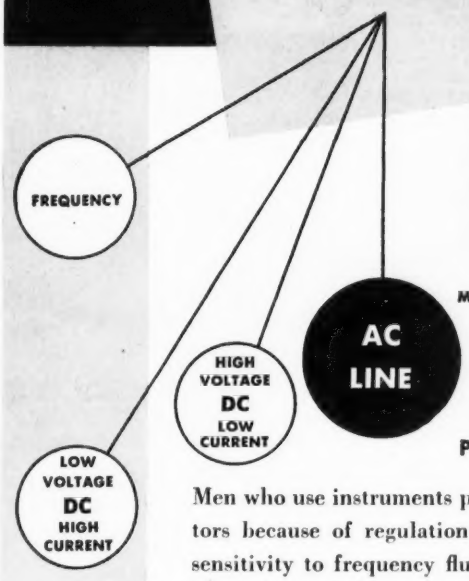
oline" can be repeated at different intervals. Instrument can be actuated by such devices as photocells, hydraulic or pneumatic switches, etc., with announcements in any interval up to five minutes. Messages can be erased and new ones recorded in one operation. Plastic-enclosed tape cartridge (cigarette-package-size) is easily inserted and removed.—*Mohawk Business Machine Co., 47 West Street, New York City.*

Mention No. 1123 when filling out card.

Automatic Apparatus for Melting-points, etc.

New "Aminco-Furst Meltometer" is said to accomplish rapidly and accurately, "for the first time," temperature-

SORENSEN electronically REGULATES AND CONTROLS



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Men who maintain instruments prefer Sorensen AC Line Regulators because of circuit simplicity, conservatively rated tubes (only 3 in all), built-in ability to deliver trouble-free performance for months on end.

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SATURABLE CORE REACTORS **AC LINE REGULATORS**

ELECTRICAL SPECIFICATIONS

Models available (numbers indicate VA capacities)	Input	95-130 VAC, 1φ,50-60~;190-260 VAC in "-2S" models
	Output	115 VAC ±5%; 230 VAC in "-2S" models
150S 250S	Regulation accuracy	±0.1% against line or load
500S (-2S also) 1000S (-2S also)	Distortion	2% - 3% maximum
2000S 3000S (-2S also)	P. F. range	Down to 0.7
5000S (-2S also) 10000S (-2S also)	Load range	0 to full load
15000-2S	Miscellaneous	Models 150S, 250S, 500S, 1000S, 5000S, 10000S, and 15000-2S are self-contained. Cabinets available for others.
1001	Regulation accuracy 0.01%, load range 0 - 1000 VA, output 115 VAC ±5%, other characteristics similar to those given above.	

* ISOTRONIC=Regulation and control of voltage, current, power, and frequency by electronic means.

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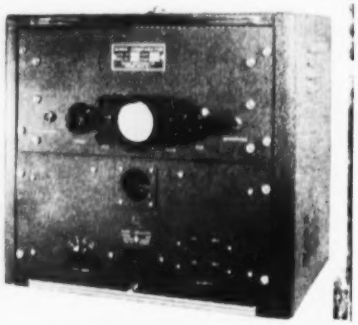
NEW INSTRUMENTS

optical transmission studies and automatic determination of melting-point, solidification point, softening point, dehydration point, decomposition point, etc. It performs many determinations automatically; minimizes personal error; reduces variables of determination to reproducible constants; measures sample size for duplication; and permits for the first time obtaining a reference value on amorphous materials with "no melting points." Transmission and temperature of sample are indicated or recorded continuosuly. A maximum of 15 minutes is required for making a melting-point determination, but only one minute for operator to insert sample and set controls—instrument does the rest. Maximum range is 0 to 500 C.; accuracy is 1 percent of pyrometer scale. (For increased accuracy, reduced temperature ranges with zero suppression.)—*American Instrument Co., Inc., Silver Spring, Maryland.*

Mention No. 1124 when filling out card.

Resonant-vibration-type Non-destructive Tester

New "Model 102 Sonic Comparator" determines natural frequency of vibration of mass-produced parts (or of individual experimental parts) within range of 100 to 10,000 cps. Body under test is continuously excited by a stylus-like prod driven from calibrated variable-frequency oscillator. Resonance is detected and displayed by cathode-ray oscilloscope whose microphone pickup does not touch body under test, therefore cannot produce frequency (or amplitude) error. Test is non-destructive; takes one-eighth or one-tenth of time of impact test in inspecting grinding-wheels, etc.; permits identifying product lots and detecting many types of invisible flaws.—*Saturn Electronics Co., 8237 Witkop Ave., Niagara Falls, N. Y.*



Mention No. 1125 when filling out card.

Oil Testing Instruments

New extensive line of equipment for petroleum testing labs is announced, all conforming to ASTM and Federal specs, some not listed in any current catalog of instrument and apparatus companies. Undersigned company offers also to modify standard designs and to custom-design and build equipment for non-standard tests.—*Technical Equipment Co., 4348 San Pablo Ave., Emeryville 8, Calif.*

Mention No. 1126 when filling out card.

Sheet-steel Drawing-quality Test Instrumentation

New "Flex-Tester," developed by Jones & Laughlin Steel Corp. metallurgists, mechanizes familiar "corner-bend test" performed manually by inspectors and by stamping-press operators, and places it on a quantitative basis. "Flex-Tester" measures, and indicates on its dial, actual resistance to a standard-dimension bend. Reading is an unquestionable indication of "drawability" and correlates with existing quantitative tests such as tensile, Rockwell, cup, etc. Diameter of bend made by "Flex-Tester" is then measured by means of a spherometer to obtain a quantitative determination of material's susceptibility to "stretcher strain" during draw.—*Steel City Testing Machines, Inc., 8843 Livernois Ave., Detroit 4, Mich.*

Mention No. 1127 when filling out card.

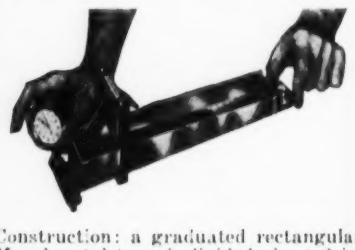
Electrically-heated Flash-point Tester

New "Electric Flash Tester," electrically-heated closed-cup tester for flash- and fire-point determinations (A. S. T. M. Method D-56) is said to represent a notable improvement over gas- or alcohol-heated testers: greater accuracy of temperature control; wide heater temperature range (100 to 700 F.); and greater safety.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*

Mention No. 1128 when filling out card.

Consistency Determination Apparatus

New "Cenco-Bostwick Consistometer" measures consistency of viscous materials by timing flow over a measured course; was originally developed for canning industry (catsup, jams, etc.) but has been found equally valuable in working with other viscous materials.



Construction: a graduated rectangular Monel-metal trough divided about 2 in. from one end into two sections by a snap-action gate. When gate is released, sample flows into graduated section; and distance it travels during one minute is noted. As moving edge is not uniform, both maximum and minimum distances are measured; average may be used to represent mean consistency of product.—*Central Scientfic Co., 1700 Irving Park Rd., Chicago 13, Ill.*

Mention No. 1129 when filling out card.

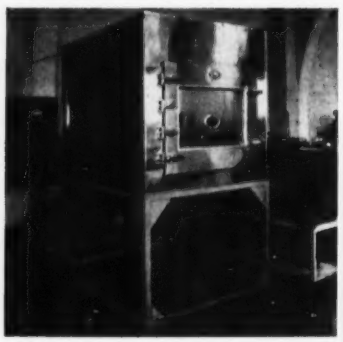
Heating-rate Regulator for Ring-and-ball Test

New "Fisher-Kermac Regulator" automatizes rate of temperature rise (9 F. deg. per minute) specified in standard ASTM Ring and Ball softening point determinations (ASTM D36-26 and Tentative-ASTM E28-42T) and prevents temperature variation greater than 9 F. deg. Natural, artificial or LP gases may be used. In each case an appropriate burner is selected and adjusted to furnish initially-required heat. Regulator has synchronous motor; adds extra heat needed by automatically increasing pressure of gas entering burner.—*Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Penna.*

Mention No. 1130 when filling out card.

Temperature Test Cabinet

New "Low-Temperature Cycling Unit" is for production-line testing of electrical apparatus at both high and low temperatures: range is from ambient to minus 165F., and can be cycled to plus 250F. Inside dimensions: 36 in. wide, 30 in. deep, 30 in. high. Visual port permits observation. Unit is said to be capable of temperature cycling from



extreme low to extreme high and back to extreme low in unusually short time. Electrical strip heating elements are adjacent to cooling coils. For safety, at beginning of heat cycle all refrigerant is automatically removed from coils. —*Industrial Freezer Div., Webber Appliance Co., Inc., 2740 Madison Avenue, Indianapolis 3, Ind.*

Mention No. 1131 when filling out card.

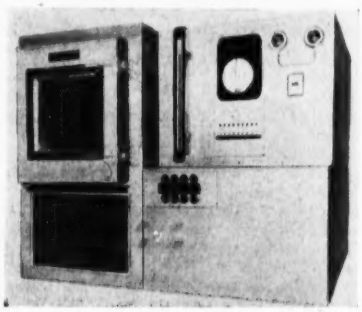
Cold Test Cabinet

New modification of chilling chamber of maker's industrial chilling machines produces complete circulation of convection fluid in chamber six times per minute, by means of a mixer mounted in rear corner of chamber. Modification will be available on special size units and on maker's standard "R-120" Model which has a thermal capacity of 2000 B.t.u's per hour.—*Sub-Zero Products, Cincinnati 29, Ohio.*

Mention No. 1132 when filling out card.

Altitude Test Chambers

New "TenneyZphere" line of altitude chambers is designed to cover majority of all altitude test requirements, thereby obviating extra cost of custom-built units. Chambers provide pressures from

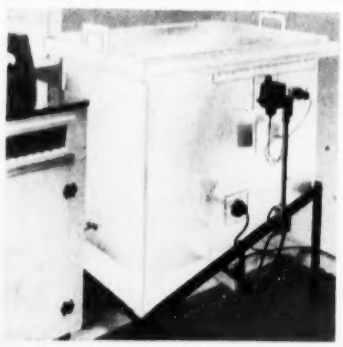


sea level to approx. 80,000 ft., temperatures from 200 F. to minus 100 F., relative humidities from 20 to 95 percent. Temperature recording controls, pressure controller and altitude gage or mercury manometer are standard equipment.—*Tenney Engineering, Inc., 26 Avenue B, Newark 5, N. J.*

Mention No. 1133 when filling out card.

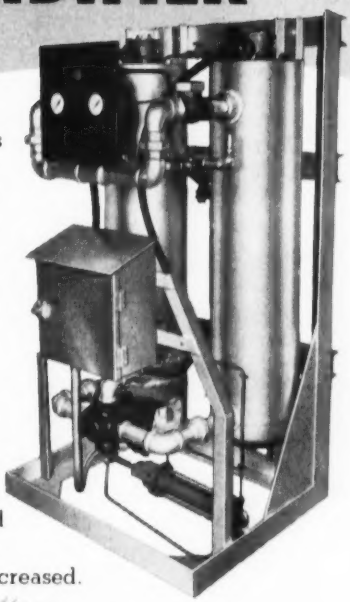
Salt-spray-test Cabinet

New "H-T Lucite Salt Spray Testing Cabinet" for fog-type spray testing of all ferrous and non-ferrous metals,



organic and inorganic coatings, is said to be inert to all solutions and gases used in complete range of fog-type testing and to last indefinitely in continuous

Keep Instrument Air CLEAN and DRY with an Industrol DYNAMIC DEHUMIDIFIER



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- Superior type of desiccant —easily replaced without dismantling unit
- Minimum maintenance
- Complete dependability
- Compact, economical, rugged
- Sizes—35 - 1500 cfm.
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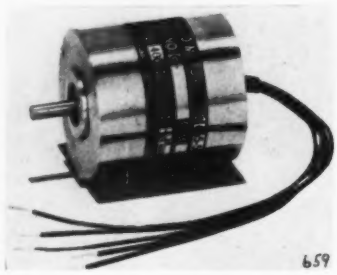
service. Cabinet is "many times" lighter in weight than other commercial types; is transparent for observing operations; is shipped ready for use. Its atomizer operates on any plant air system; its heater on 110-volt supply. Inside dimensions 36 x 24 x 36 in. deep.—*Singleton Co., 10516 Western Ave., Cleveland, Ohio.*

Mention No. 1134 when filling out card.

Small Precision Servomotors

New "Precision Motors" are 1.7 in. diam. and 1.75 in. long, for frequencies from 60 to 400 cps., and in 2-, 4- or 8-pole construction. Stall torque is approx. 2 in.-oz. Housings are stainless steel or aluminum. Output shaft can be



supplied with or without integral pinion. Units can be supplied to meet military specs. with regard to humidity, temperature, range, vibration and altitude.—*G-M Laboratories Inc., 4300 N. Knox Ave., Chicago 41, Ill.*

Mention No. 1135 when filling out card.

Predetermined-weight 2000-mg. Scale

New "Model UAB 9060 Shadowgraph," for fast precision weighing in arsenals and industries, is especially adapted for hand-filling extremely small packages, or individual check-weighing of small articles. Capacity 2000 mg.; sensitivity 1 mg. Dial is of over- and-

under type without value graduation other than exact-weight point which is set at beginning of a run. Commodity container is 1-in. stamped aluminum pan 0.25 in. deep, with pouring spout and handle.—*The Exact Weight Scale Co., Columbus 8, Ohio.*

Mention No. 1136 when filling out card.

Tachometer with Overrange Protection

New model of "Smiths" magnetic (eddy-current type) hand tachometer is furnished with a limit stop for drag cup. Since there is no mechanical connection between drag cup and revolving Alnico magnet, when overranged, magnet merely revolves at a faster speed inside drag cup which is held against limit stop. Other features: extremely low torque requirement; push button pointer arrestor.—*Equipoise Controls, Inc., P. O. Box 269, Bronxville, N. Y.*

Mention No. 1137 when filling out card.

Basic Scaler

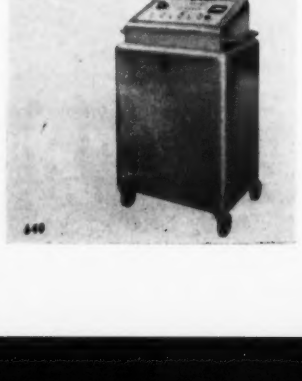
New "SC-19 Utility Scaler" is a simple basic scaler for laboratories interested in entering field of radioactivity at minimal cost. It has a regulated high-voltage power supply for Geiger tubes. It uses eight elec-

tronic scales-of-two, giving a scaling factor of up to 256, followed by a mechanical register. Scale selector switch allows choice of four scaling factors of 32, 64, 128 and 256. Total count is obtained by multiplying register reading by selected scaling factor and adding values of neon interpolating lights. Predetermined counts from 320 to 256,000 may be selected. Special connectors permit use of a separate clock operated by count-stop-reset switch or a preset timer. Resolving time, about 10 microseconds; maximum counting rate 1,000 cpm. on register.—*Tracerlab, Inc., 130 High Street, Boston, Mass.*

Mention No. 1138 when filling out card.

Instrumentation for Medical Isotope Applications

New "Scanographs" are scintillation detection units designed specifically for medical, clinical, and research programs; provide all basic equipment in one instrument for a diagnostic isotope

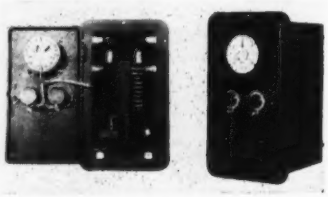


service: thyroid uptake measurements, brain-tumor localizations, blood-volume studies, etc. Illustrated unit ("Model C-2000") comprises: (1) counter employing a large sodium-iodide thallium-activated crystal; (2) flexible counterbalanced arm which supports counter with or without lead collimating cap; (3) scintillation scaler incorporating (a) linear amplifier, (b) pulse-height discriminator, and (c) regulated high-voltage power supply.—*Nuclear Research and Development, Inc., 1094 Sutter Ave., St. Louis 5, Missouri.*

Mention No. 1139 when filling out card.

Differential-voltage Indicator

New indicator measures differential voltage, as well as amperage, speed, pressure, and other variables which can be converted to voltage. Basically a high-resistance precision voltmeter containing an electronic amplifier, it fea-

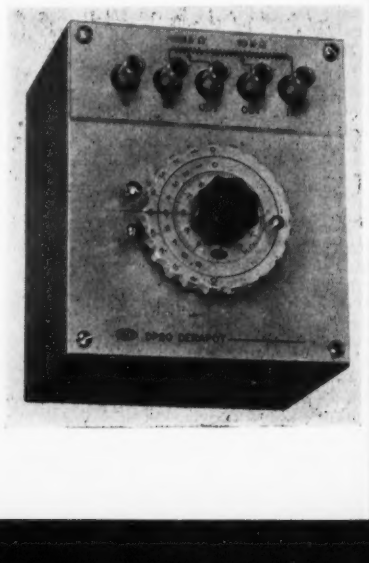


tures a self-balancing circuit said to possess a high degree of stability and freedom from drift. It is capable of measuring a 0.001-30 volt differential of two input voltages ranging from 1 to 400 volts, if they do not differ by more than 300:1. It can indicate full-scale for voltages as small as 0.022 volt. Scale can be marked in volts, amps, feet per minute, etc. Used with standard accessories, such as a recorder, indicating instrument, or alarm relay, new differential-voltage indicator will record deviations at a point remote from installation, or sound an alarm when deviations occur.—*General Electric Co., Schenectady 5, N. Y.*

Mention No. 1140 when filling out card.

Precision Variable Resistors and Voltage Dividers

New "Dekapots" feature unique "Beco Dekadial" which has an effective scale length of more than 400 in., permitting reproducible settings of proper combination of precision fixed resistors

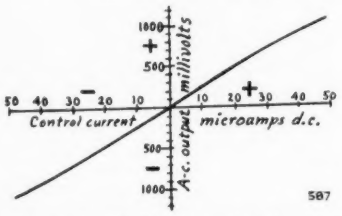


and a supplementary precision variable resistor to obtain desired value. "Dekadial" may be read directly to four places and a fifth place may be estimated. Over-all accuracy better than 0.05 percent of full scale. Cased "Dekapots" available as stock items; units for panel mounting as components of other equipment can also be provided. —*Brown Electro-Measurement Corp., 4635 S. E. Hawthorne Blvd., Portland 15, Oregon.*

Mention No. 1141 when filling out card.

Magnetic Amplifier

New "IMM-182," developed especially for control-instrumentation uses, converts d-c. microampere signals to 400-

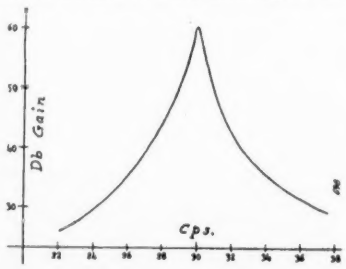


cps. output suitable for actuating indicating or recording instruments, or for commanding a reversible two-phase servomotor.—*General Magnetics, Inc., 135 Bloomington Ave., Bloomfield, N. J.*

Mention No. 1142 when filling out card.

Resonant Amplifier for A-c. Servomechanisms

New "Model 504 Twin-T Servo Stabilizer" is a new type of resonant amplifier giving high-Q performance at low frequencies as well as at audio frequencies; is available in a plug-in package 2 x 2 x 4.75 in. It employs well-known method of incorporating a Twin-



T filter in feedback loop of an amplifier, but novel direct-coupled features give stable values of Q up to 100 plus feedback stabilization of gain even at peak of frequency-response curve. A typical response curve for a 30-cycle amplifier is shown.—*Kalbfell Laboratories, Inc., P. O. Box 1578, San Diego 10, Calif.*

Mention No. 1143 when filling out card.

Electrically-controlled Variable Inductor

New "H3M 3H9L Increductor" controllable inductor has maximum inductance, at zero control current, of 30 mh. which can be reduced to 1/400th of this value with 100 ma. peak control current. Corresponding frequency variation is 20 times starting frequency. Approximate range of starting frequencies for zero current is between 10 and 100 kc. New unit features a linear re-

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D-79 GAUSSMETER

This precision built instrument measures flux density, determines direction of flow. It locates and measures stray fields and plots variations in strength and checks production lots against a standard. Simple to operate. No ballistic readings . . . no jerking or pulling. Supplied with protective carrying case.

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- Net weight only 10-1/2 lbs
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STANDARD TYPES IMMEDIATELY AVAILABLE

Typical application in capsule form for temperature sensing of hydraulic oil.

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.140 x ¾	45 ohms	86 ohms	194 ohms
.040 x 1.5	12,250 ohms	26,200 ohms	65,340 ohms
.018 x 1.5	35,000 ohms	82,290 ohms	229,600 ohms

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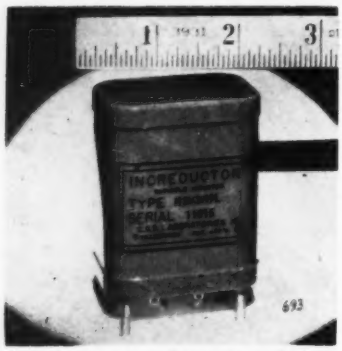
NEW INSTRUMENTS



lationship between frequency shift and control current extending over at least a 5:1 change of frequency.—*C. G. S. Laboratories, Inc.*, 391 *Ludlow St., Stamford, Conn.*

Mention No. 1144 when filling out card.

D-c. Chopper Amplifier

New "Model 300 Universal Chopper Amplifier" has a maximum gain of 800,000; frequency response of 0-500 cps.; input impedance of 1 megohm; noise and drift within 25 microvolts, or 2 percent of full-scale output; stabilized gain; new 5000-per-second mechanical chopper. Input bucking potential includes both step and continuous controls, allows zero to be offset 150 times full-scale. Output will deliver up to 25 ma., can develop ±80 volts, works well into CRO, will drive practically all recording galvanometers. Series and damping resistor terminals permit attenuating output to work with sensitive mirror galvanometers. Terminals are also provided for equalizing recorders. —*Keithley Instruments*, 3868 *Carnegie Avenue, Cleveland* 15, *Ohio.*

Mention No. 1145 when filling out card.

Wave and Pulse Generator

New "Model G-101 Syncroplex" is a multi-waveform generator and pulse synchronization unit which provides, at

repetition rates of 1 cps. to 100 kc.: (1) sawtooth waves, (2) square waves or square pulses, one microsecond to one second duration with rise time of 0.15 microsecond, (3) integrated or differentiated versions of square waves and pulses. All outputs are simultaneously available, independently variable in amplitude, may be synchronized, triggered or gated by sine waves, pulses or other complex waveforms.—*Television Equipment Corp.*, 238 *William St., New York* 38, *N. Y.*

Mention No. 1146 when filling out card.

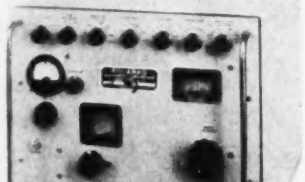
Decade Inductor Units

New "Series 700" decade inductor units embody new coil-switching method which has lowered costs (and prices), but units have better characteristics than previous series. Four units are announced, in ranges from 10 x 0.001 henry to 10 x 1 henry. With all four in series, 11,110 steps from 0.001 henry to 11.11 henries are obtained. Optimal frequency ranges from 400-20,000 to 400-5000 cps. Standard tolerance 1 percent; 0.05 percent tolerance available on request. Reasonable amounts of dc. may flow through units with small effect on inductances.—*Hycor Co., Inc.*, 11423 *Vanowen St., N. Hollywood, Calif.*

Mention No. 1147 when filling out card.

Microwave Signal Generator

New "Model MSG-4" microwave signal generator covers frequency range from 7,000 to 10,750 Mc.; is a continu-

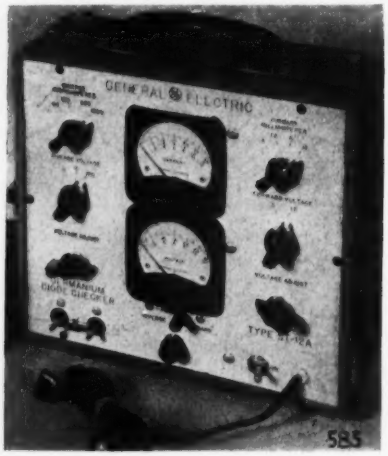


ously-variable direct-reading instrument utilizing single-dial control and noncontacting shorts on klystron cavity. Internal pulse and frequency modulation available as well as delayed and undelayed sync signals.—*Polaroid Electronics Corp.*, 100 *Metropolitan Ave., Brooklyn* 11, *N. Y.*

Mention No. 1148 when filling out card.

Germanium Diode Tester

New "Type ST-12-A," for checking static characteristics of germanium diodes, has other uses, such as general resistance checking, an accurately metered power supply, and forming electrolytic capacitors and checking d-c. leakage current. Diode resistance is checked by placing a variable direct voltage across diode; resulting cur-

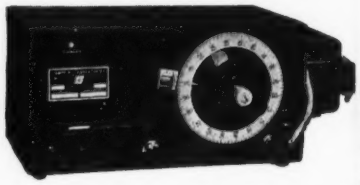


rent is indicated. Forward and inverse circuits are entirely separate. A diode may be checked to test limits in both forward and back direction by moving a lever switch; thus eliminating both reversal of diode in clips and any major readjustments of controls.—*Dep't N-12, Inquiry Section, General Electric Co., Electronics Park, Syracuse, N. Y.*

Mention No. 1149 when filling out card.

Frequency Meter

New "Type 105-B Micrometer Frequency Meter" measures center frequency deviation on any number of FM

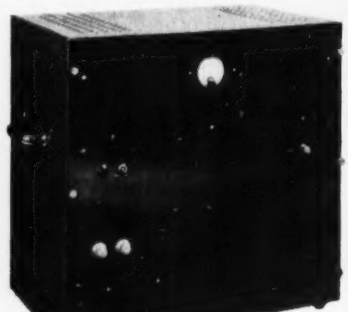


or AM transmitters, throughout a continuous range of frequencies, 0.1 Mc. to 175 Mc. It supersedes "Type 105-A", retaining features such as micrometer capacitor and Cady crystal oscillator circuit. A stage of audio amplification and a function selector switch are said to accomplish (1) increased sensitivity when measuring frequency of VHF transmitters, (2) higher output for feeding into VHF receivers for alignment purposes, and (3) strong headphone signal when calibrating against internal crystal standard, permitting settings to better than 1 part per million.—*Lampkin Laboratories, Inc., Bradenton, Fla.*

Mention No. 1150 when filling out card.

0.01-100-cps. Oscillator

New "Model L" oscillator is a source of power continuously variable from 0.01 to 100 cps. in eight overlapping ranges. Two output circuits: one will deliver 20 volts or 20 ma. rms. and will deliver 20 volts across 1000 ohms (20 mv. across 1 ohm, etc.) without increase in distortion; second has constant internal resistance of 300 ohms

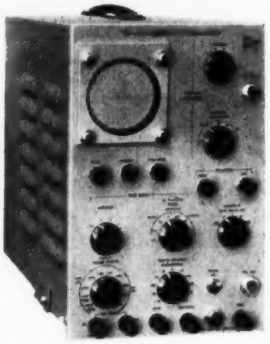


and approx. 1-v. open-circuit voltage. Oscillator comprises two chassis: top chassis contains regulated power supply, electron tubes and other heat-generating components; lower chassis contains frequency-determining network etc.—*Southwestern Industrial Electronics Co., P.O. Box* 13058, *Houston* 19, *Texas.*

Mention No. 1151 when filling out card.

Laboratory Oscilloscope

New "Type 315-D" is a precision laboratory oscilloscope in a small (35-lb.) package. Electronic regulation of



all dc. voltages provides stability over supply voltage range of 105-125v, 50-400 cps. New time base generator has extremely wide range of 1 microsecond to 50 seconds. New 5x magnifier expands time base to left and right of center. Direct-coupled trigger amplitude discriminator allows trigger phasing on complex waveforms. Direct-coupled unblanking circuit insures constant beam current. Time base accuracy is independent of duty cycle. Waveform voltages can be accurately read directly from screen on nine calibrated ranges, from 0.02v. to 100v. per division. Risetime is 0.07 microsecond. Signal delay is provided. "315-D" contains a square-wave voltage calibrator, uses a high-definition 3-inch c-r. tube.—*Tektronix, Inc., P. O. Box 831, Portland 7, Oregon.*

Mention No. 1152 when filling out card.

Wide-band High-gain C-r. Oscilloscope

"Type 303-A Oscillograph" is a wide-band high-gain cathode-ray oscilloscope designed specifically for study of pulses

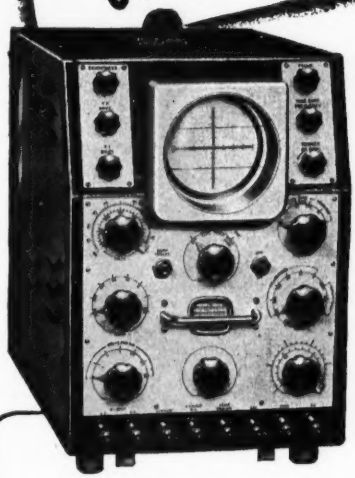
and other high-speed phenomena; is equipped with circuits for precise quantitative measurement of both time and amplitude. Signals as high in frequency as 20 Mc. or more may be usefully displayed. Sweep durations are variable from 0.1 second to 2 microseconds. With maximum expansion (6 times full-screen diameter) sweep speed is 10 inches per microsecond. Higher sweep speeds obtainable at some sacrifice in positioning and linearity but not in

Instantaneous Comparisons

WITH THE

COSSOR DOUBLE BEAM

AC. & DC. Oscilloscopes



Precision-Built for Industry and Laboratory

Cossor Double Beam (direct coupled) Oscilloscope Model 1049 provides simultaneous display of related phenomena, permitting *instantaneous* comparisons.

Independent Y 1 and Y 2 direct coupled amplifiers, each having flat response from zero to 100 kcs., ±1db. Up to 1000V. dc. or ac. peak can be fed into the 1 megohm, 70 mmf. Y 2 input. For special uses the beam can be activated by dc. externally, or by line frequency to give line frequency marker pips.

Continuously variable sync. control uses either negative or positive pulses. Repetitive, triggered or single stroke operation. Directly calibrated 9 range time scale provides 1.5 seconds to 150 micro-seconds.

Once triggered, sweep is independent after the initial pulse, thus avoiding velocity modulation of beam.

CRT Sensitivity: Y plates 3v. per mm.; X plates 2.5v. per mm. Alternative CRT voltage 2 or 4kv. provided. Stabilizes 10% fluctuations in line voltage operating conditions in 5 to 10 minutes, an important field use feature. Flat face tube. Power Rating 110-245 volts ac., 40-100 cps.; 130 watts. **889.50**

MODEL 1035 FOR GENERAL PURPOSE APPLICATIONS

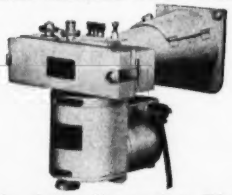
Displays two different sets of data on one screen simultaneously. **DESIGN DATA:** Y 1 amplifier, ac. coupled; 7 direct reading voltage scales from 50 mv. to 50v. accurate within ±1 db. from 20 cps. to 7 mcs.... at 10 mc. it's only 3 db. down!

Y 2 amplifier, ac. coupled; 5 ranges, 5v. to 500v. ... 20 cps. to 100 kc. ±1db.

Sweep Circuits in 9 ranges provide 15 micro-secs to 150 millisecs, ±0.5db.

Sync. control from positive or negative sources; repetitive rate and trigger operation are invaluable for radar display problems. Time, speed and voltage are all easily read from directly calibrated scales. A pulse derived from the sweep signal increases brilliance during forward beam travel and provides positive blanking during retrace. Direct connection to CRT plates; all sweep and control voltages available externally. Flat face tube. Operates on 105-130v., and 200-255v., 50-100 cps. **599.50**

MODEL 1428 CAMERA AND MODEL 1431 DRIVE



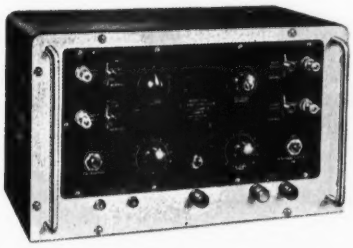
Ideal for photographing transients. Either sweep synchronized, triggered pulses, or continuous non-recurrent waveforms and transients can be captured on 25 foot rolls of standard 35 mm. film or oscillograph recording paper. Operation: manual or motor driven.

Can be daylight loaded for "Time" and "Bulb" as well as beam triggered exposures.

Used in conjunction with the Cossor Drive Unit Model 1431, all types of instantaneous or continuous phenomena can be photographed. Accurate gear selection by "shift" knob, and positive drive and film transit, assure 100% operation at all times. Film speed .05 to 25 in. per second. Capacitor type motor provides freedom from electrical interference.

MODEL 1428 CAMERA 245. **MODEL 1431 DRIVE 306.**

MODEL 1430 PRE-AMPLIFIER



Used in conjunction with Cossor Model 1049 Oscilloscope for measuring minute dc. voltages, provides a gain of 45,000 with a maximum sensitivity of greater than 0.75 mV./cm. and a response flat within ±1db., dc. to 30 kc. Any combination of balanced and unbalanced input and output can be selected by switching. A 1 mV. calibration signal is available for calibrating the recording system.

Operating from standard A and B batteries the high-gain amplifier is completely free from spurious hum and other effects of line ripple. **390.45**

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time-measurement accuracy, since calibration is accomplished by signal substitution. A controllably-illuminated calibrated scale is standard equipment; also a filter of a color appropriate for screen type provided with individual instrument; also "Type 2592-52" shielded coaxial adaptor with 52-ohm termination.—*Instrument Div., Allen B. DuMont Labs., 1500 Main Ave., Clifton, N. J.*

Mention No. 1153 when filling out card.

Miniature Three-element Oscilloscope for Aircraft

New 'Model 310 Dynamic Meter," designed to present flight test data for either visual or photographic observation, is a miniature three-trace light-beam single-axis oscilloscope for airborne use, mounted on a standard AN 2.75-in. instrument bezel. Extremely

sensitive galvanometers produce appreciable deflections from conventional strain-gage signals without amplification. Light intensity of edge-lighted Lucite screen may be adjusted for optimum contrast between signal spots and screen graduations. Owing to symmetry and balance of galvanometers, instrument is virtually insensitive to angular and lateral accelerations experienced in piloted aircraft. Weight, 2.3 lbs.; optical-arm distance, 4.8 in.; power required, 24 v. 1.5 amp.—*Midwestern Geophysical Laboratory, Tulsa, Okla.*

Mention No. 1154 when filling out card.

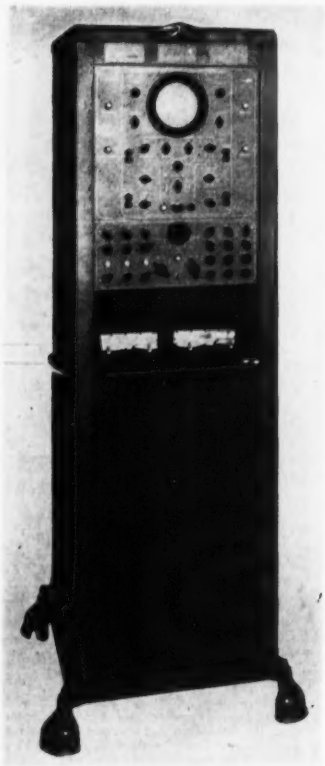
Oscillograph for Severe Shock and Acceleration Conditions

New "Model 560" oscillograph, designed to record under extreme shock and acceleration conditions, was subjected to tests at Naval Ordnance Lab., which reported: "Fourteen tests were conducted, in which the oscillograph was subjected to single-phase shock conditions from 50 to 100 g's and to two-phase shock conditions from 100 to 500 g's. The oscillograph continued to record throughout the complete tests." New instrument is capable of making 12 simultaneous records although its width (less mounting flanges) is 4.875 in., height 5 in. and length 7 in; weight 8.25 lbs. Recording film width 3.5 in., length 40 ft. (Kodak V-206). Among other features: choice of three film speeds; 12-channel magnetic assembly with facilities for mounting damping resistors for each channel inside oscillograph; all operating controls and viewing screen accessible from one end; large variety of galvanometers available, undamped natural frequencies up to 3500 cps.—*Midwestern Geophysical Laboratory, Tulsa, Okla.*

Mention No. 1155 when filling out card.

C-r. Oscilloscope with Magnetic Memory

New "Type MS-10A" of "Memoscope" records magnetically wave shapes and signal traces for instantaneous reproduction on its c-r. tube screen; has new frequency converter to record magnetically frequencies as high as 10 Mc. without harmonic distortion.—*Millivac Instrument Corp., 444 Second St., Schnectady 6, N. Y.*



Mention No. 1156 when filling out card.

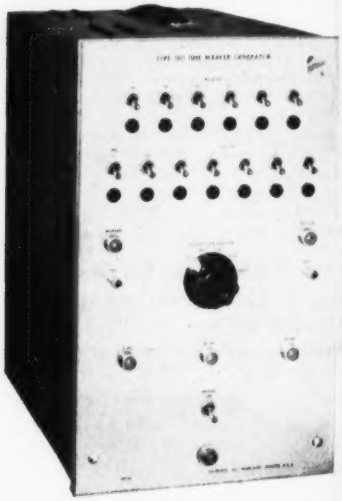
Crosshatch-pattern Generator

New "Model 485" crosshatch-pattern generator permits TV-receiver horizontal and vertical linearity, hold, height, width and drive adjustments to be made easily and quickly when transmitter test patterns are not available. It provides a synchronized signal, modulated on carrier frequencies of channels 2 through 6, which can be tuned and sent through receiver under test. When receiver has been properly adjusted, signal will show equally-spaced lines in vertical, horizontal or cross-hatch patterns on picture tube.—*Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.*

Mention No. 1157 when filling out card.

Time-mark Generator

New "Type 180 Time Mark Generator" has time markers of 1, 5, 10, 50, 100, 500 microseconds; 1, 5, 10, 50, 100, 500 milliseconds; and 1 second; all available separately and simultaneously through pin jacks or mixed in any combination through UHF connector; sine-wave outputs of 5, 10 and 50 Mc.; trigger impulses of 1, 10, 100 cps., 1, 10, 100 kc. through UHF connector; all outputs controlled by a 1-Mc. crystal accurate within 0.02 percent.—*Tektronix, Inc., P. O. Box 831, Portland 7, Oregon.*



Mention No. 1158 when filling out card.

Recording Cameras for C-r. Oscilloscopes

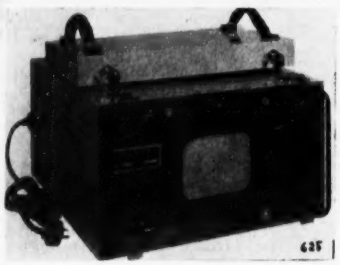
Four new "Oscillograph Record Cameras" are announced: "Type 295" is for single-transient recording with writing rates as high as 180 inches per microsecond, makes 40 exposures from a standard 36-exposure cassette. Portion of film may be developed while subsequent exposures are being made. Binocular viewing is possible while recording. "Type 296" for single-frame recording supersedes "Type 271-A," permits most versatile and inexpensive technique with simultaneous viewing

nd recording. "Type 297" has "Polaroid Land" camera-back and furnishes inished print in less than a minute; educes recorded image to one-third f object size. "Type 321" is a moving-ilm camera on a stand (floor or bench-op), may be rotated 90 degrees to make oriz. or vert. records without rotating r. tube or reversing deflection-plate eads; takes 400 ft. of perforated or lain 35-mm. film or paper. Both load nd take-up magazines can be detached n a few seconds. Utmost simplicity of ilm loading: no threading. Film speed ariable in 18 steps from about 1 in. er minute to about 15 ft. per second. ime calibration may be made by a ashing glow lamp.—*Instrument Div., llen B. Du Mont Labs., Clifton, N. J.*

Mention No. 1159 when filling out card.

Portable TV Monitor

New "Model 102-C" portable picture monitor has 7-in. kinescope, will present a TV picture of black and white, or color signals in black and white, at the turn of a switch. Kinescope may be

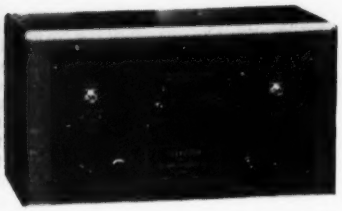


removed from front and all parts accessible. Input signal 1 volt peak-to-peak; input impedance 470,000 ohms; resolution in excess of 450 lines.—*Polarad Electronics Corp., 100 Metropolitan Ave., Brooklyn 11, N. Y.*

Mention No. 1160 when filling out card.

Frequency Dividers

New "Decaviders" make possible frequency counting in higher ranges with equal precision. No additional signal



level is required and there is no loss of accuracy. "Decaviders" are connected in series with input of standard frequency counters, whose ranges are thereby extended.—*Decade Instrument Co., Caldwell, N. J.*

Mention No. 1161 when filling out card.

Low-pass Filters

New "Series F-10" filters feature low attenuation in pass band, 55-db attenuation in rejection band, linear phase transfer, and high characteristic impedance; are three-section constant-K networks designed for general laboratory use but more specifically for use with "Glennite" accelerometers and

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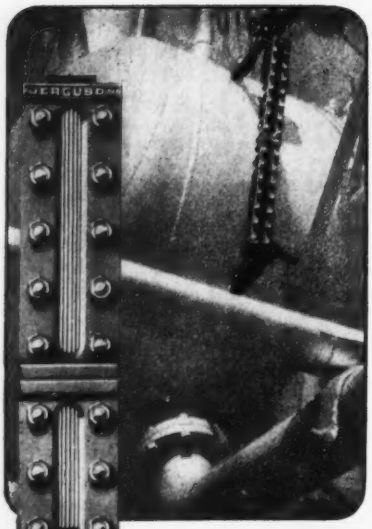

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NEW INSTRUMENTS

617

cathode followers for shock and vibration measurements. Use of finest high-Q toroids commercially available results in extremely sharp cutoff characteristics.—*Gulton Mfg. Corp., Metuchen, N. J.*

Mention No. 1162 when filling out card.

Toroidal Power Transformer

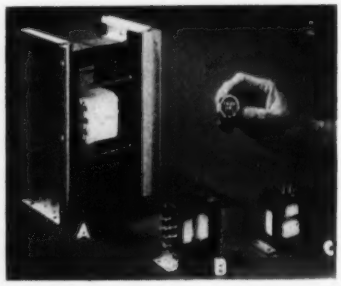
New "Model MT-1001" toroidal power transformer replaces ordinary power transformers in high-gain amplifiers

where it is desired to minimize hum-pickup through magnetic field radiation. Unit is precision-wound on a ring core without air-gaps and radiates less than 0.01 gauss at 5 in. from its surface. By parallel or series connection and doubler or tripler circuits, 350, 700, 1,200 and 1,800 volts d.c. for plate supply may be obtained. Two separate heater windings are rated 6.3 volts and 1.5 amp.—*Millivac Instrument Corp., 444 Second Street, Schenectady 6, N. Y.*

Mention No. 1163 when filling out card.

Ferrite-core Transformers

New specialized transformers, of design based on ferrite magnetic cores and tetafluoroethylene insulation, are said to give application advantage (1) where r-f circuitry requires impedance matching over a wide impedance and/or frequency range, (2) where r-f or audio applications require electrostatic shielding between windings, extremely high voltages, or especially small dimensions. Leakage reactance of new types runs approximately 10 percent that of equivalent conventional transformers. Size and weight are generally less than those of conventional types. Functionally, new transformers are capable of operation with internal temperatures up to 160 C., are impervious to damage by moisture absorption or fungus attack.–*Sierra Electronic Corp., 831 Brittan Ave., San Carlos, Calif.*



Mention No. 1164 when filling out card.

Regulated D-c. Power Supply

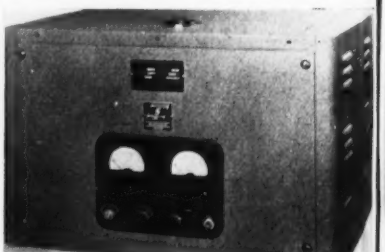
New "Model M30" continuously-variable 0-325-volt electronic regulated d-c. power supply has a direct current rating of 150 ma. and also a low-voltage a-c. output of 6.3 volts at 6 amps. Voltage regulation is within 0.5 percent from 30 to 325 volts from no-load to full-load; ripple is less than 2 mv.—*Perkin Engineering Corp., 345 Kansas Street, El Segundo, Calif.*

580

Mention No. 1165 when filling out card.

Low-voltage High-current Regulated D-c. Supplies

New "Models E-6-5A, E-6-15A, E-6-40A, and E-6-100A Nobatrons" convert nominal 115-v. ac. line to 6-v. dc. adjustable plus or minus 10 percent, at currents of 5, 15, 40 and 100 amps. respectively, and with a regulation accuracy of 0.2 percent. New feature: a front-panel switch instantly changes output from 6 to 7 v. dc. adjustable plus or minus 10 percent, for instruments and other devices which operate at an actual 7 volts rather than a nominal 6 volts.—*Sorenson & Co., Inc., 375 Fairfield Ave., Stamford, Conn.*



677

Mention No. 1166 when filling out card.

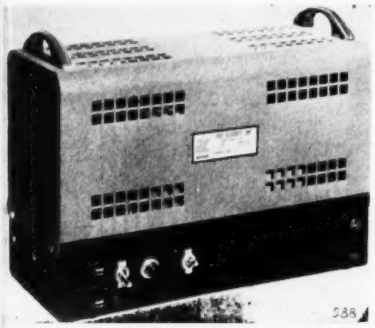
Battery Charger

New battery charger, housed in metal cabinet 8 x 7 x 5 in., weighs 10 lbs., has no moving parts or tubes, is merely plugged into a-c. outlet and clipped to battery.—*Electronic Rectifier Co., 1462 East Main St., Rochester, N. Y.*

Mention No. 1167 when filling out card.

Voltage Regulator

New "Model 116" a-c. line voltage regulator suitable for regulating voltage to analog computing set-ups, servo



systems, etc., regulates line voltage to 0.01 percent; has a transient time constant of less than 0.01 second; may be used on either 60-cycle or 400-cycle lines; has a power handling capacity of 100 v-a.—*Avion Instrument Corp.*, 299 *State Highway* 17, *Paramus, N. J.*

Mention No. 1168 when filling out card.

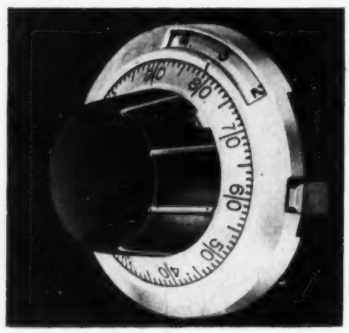
Enclosed Relay Racks

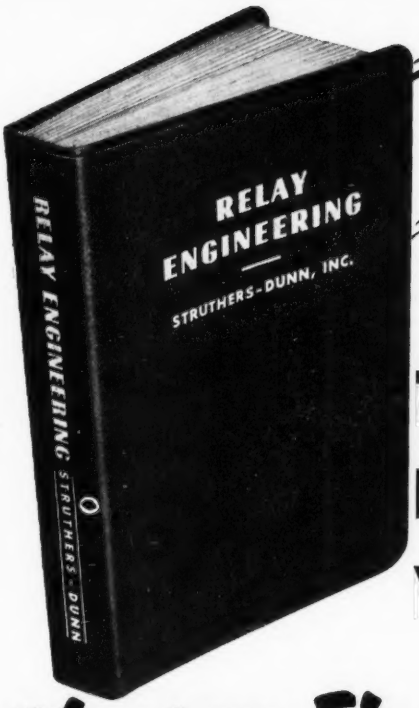
New enclosed relay racks are rigidly constructed of 16-gage cold-rolled sheet steel; panel-mounting angles of 12-gage steel are tapped for 10/32 machine screws on Western Electric spacings. Panels fit into a recess so that edges are not exposed; rear doors are closed by a flush snap catch. Cabinets are available with square corners or with front vertical rounded corners; are shipped knocked down with all necessary bolts for easy assembly.—*Premier Metal Products Co.*, 3160 *Webster Ave., Bronx* 67, *N. Y.*

Mention No. 1169 when filling out card.

Turns-indicating Dial for Multiturn Devices

New "Model RA Precision Duodial" features glare-free satin-chrome finish, instantaneous movement of secondary (outer) scale, large black nylon knob, vibration-proof lock, and ease of reading. Secondary scale (turns-counter) remains stationary until primary scale is about to complete a single revolution, at which point a jump gear turns secondary to next digit. When used with a 10-turn instrument such as "Model A Helipot," dial reads directly to three decimal places and fourth place can be interpolated. Positive vibration-proof locking mechanism can be set by same hand that manipulates knob. New





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ECONOMICAL — No tube filaments to consume power during "OFF" cycle.

VERSATILE — High contact pressure on silver contacts allows conservative rating of four (4) amperes, with a choice of either opening or closing a circuit, or to simultaneously open one and close another.

AUTOMATIC HOLD CIRCUIT — Connecting terminals provide a choice of conventional relay action, or allow a momentary contact to energize relay and cause it to automatically remain energized until manually reset by "Reset" switch.

APPLICATIONS

LIQUID LEVEL CONTROLS
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STOP MOTIONS
DROP WIRE DETECTION

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NEW INSTRUMENTS

dial is completely assembled at factory; is suitable for use with devices having as many as 15 turns; fits equipment having 0.25-in. diameter shaft and is also available in RAJ version for devices having 0.125-in. shaft.—*Helipot Corp., South Pasadena 8, Calif.*

Mention No. 1170 when filling out card.

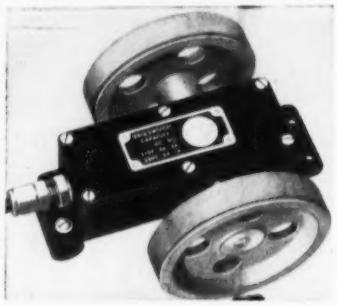
Magnetic-tape Splicer

New "MT-1 Presto Splicer" cuts and splices quarter-inch magnetic recording tape, utilizing a method based on a combination of electric heat, controlled pressure, and controlled time cycle, producing a diagonal-splice plastic weld without adding to thickness of tape or using tape material for weld. No "bloops" are created: properties of tape are not affected and splice is inaudible even with playback amplifier at maximum gain. Also, tape retains its original flexibility. Unit operates on 115-volts 50/60-cps. a.c. with automatic line voltage compensation. Each splice takes from 4 to 5 seconds, plus 5 seconds to permit tape to cool off.—*Prestoseal Mfg. Corp., 38-01 Queens Blvd., Long Island City, N. Y.*

Mention No. 1171 when filling out card.

Lineal Measuring Actuators for Electric Counters

New electric-counter actuating switches are equipped with wheels for use in measuring paper, fabrics, lumber, etc.



Each revolution of wheels closes and opens switch, providing impulse to register one count in an electric counter (not illustrated). Wheels are normally 12 in. in circumference, permitting counter to register feet. Other sizes available. Contact springs are of nickel-silver with silver points, rated at 10 amps. 115 volts a.c.—*Production Instrument Co., 702 W. Jackson Blvd., Chicago 6, Ill.*

Mention No. 1172 when filling out card.

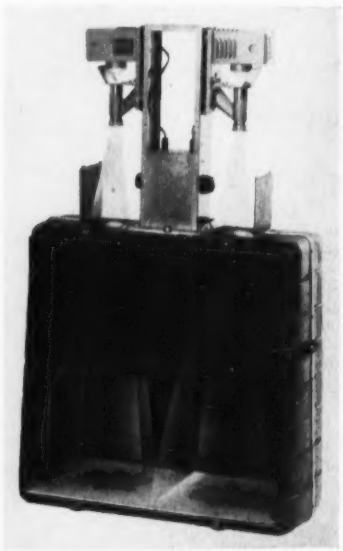
Gaging Head for Air Gages

New "Plunjet" gaging head, for use with "Precisionaire" and other makes of air gages for gaging wide-tolerance work, can be adapted to a wide range of applications; is calibrated by a feeler gage having max. & min. limit elements. Two types are available: normal and the reverse, in three standard ranges: 0.040, 0.020, 0.010. "Plunjets" for special ranges and closer tolerances can be supplied on special order. —*The Sheffield Corp., Dayton 1, Ohio.*

Mention No. 1173 when filling out card.

Surface Comparator

New "Model BL-122" of maker's "Faxfilm" surface comparator offers greater flexibility in use and increased portability. Basic method is unaltered: a clear plastic replica of a surface is made in about a minute and projected in a microprojector to show minute details of surface condition with marked



three-dimensional effect. New model provides comparison projection of two "Faxfilm" replicas at 30-diameter magnification; is 25 x 12 in. at base and 22.5 in. high. Including accessory and file case carried in base of unit, total weight is less than 30 lbs. For travel use, when comparison projection is not required, one projector may be removed from large unit and carried in small accessory case: total weight less than 8 lbs.—*Instrument Div. 33G, Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio.*

Mention No. 1174 when filling out card.

10-in. and 1-in. Optical Flats

New optical flats extend maker's line (2, 3, 4, 5 and 6 in.) at both ends: one is 10 in.; the other is 1 in. Three ac-

curacies are available: one, two, and five millionths of an inch. Flats may be obtained with one or both surfaces lapped to stated accuracy, are manufactured of pure fuzed Brazilian quartz selected for clarity.—*The DoALL Company, Des Plaines, Ill.*

Mention No. 1175 when filling out card.

Illuminated Magnifier

New electrically-lighted magnifier for industrial use comes equipped with either of two types of illuminator han-

dles: one battery-powered, the other for 110 v.ac. Either handle fits a reflector-type shade into which magnifier snaps. Accessories furnished without extra cost are a non-illuminating handle and a metal tripod. Lens system magnifies five times; has a wide, flat field; is highly corrected to eliminate virtually all spherical and chromatic aberration and distortion.—*Bausch & Lomb Optical Co., Rochester, N. Y.*

Mention No. 1176 when filling out card.

Inspection Magnifier

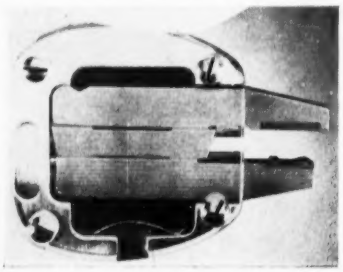
New "Model 220" Magnifier has six-power achromatic magnification with two-inch field of vision; is made of

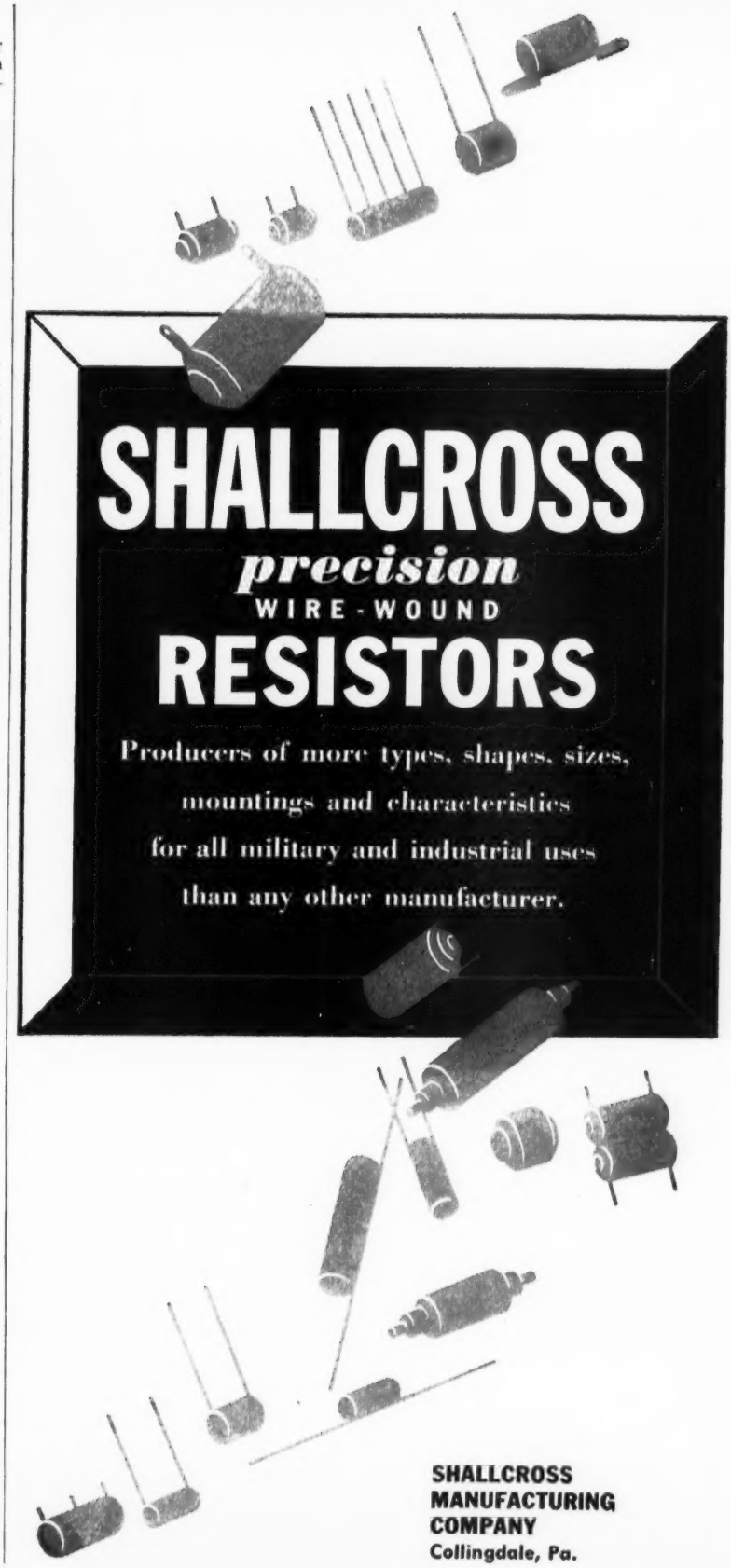
laminated plastic; concentrates light on object from adjacent light sources by curved sides of Lucite base; weighs 8 oz.—*Mfg. Div., Larrimore Sales Co., P. O. Box* 1234, *St. Louis* 1, *Mo.*

Mention No. 1177 when filling out card.

Adjustable Limit Gage

New "Brandt" adjustable limit gage is said to hold its adjustment indefinitely even in constant daily use; consists





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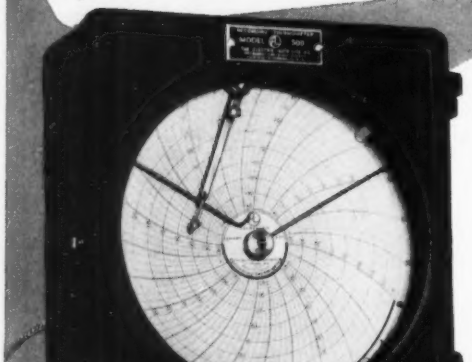

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NEW INSTRUMENTS

of two measuring members separated by a wedge and clamped securely within a frame. Slope of wedge is selected so that a large displacement of measuring member relative to wedge is required for a small adjustment of the measured distance. Gage is being manufactured in Europe; manufacturing licenses offered by *Philips Laboratories, Inc.*, 100 *E. 42nd St., New York* 17, *N. Y.*

Mention No. 1178 when filling out card.

Micrometer Caliper

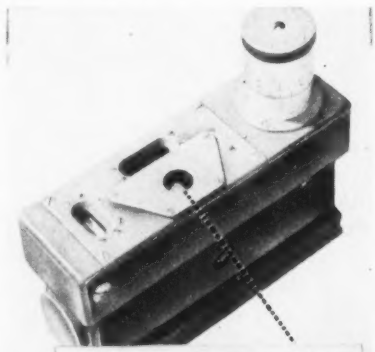
New "Steinmeyer Precision Micrometer" (made in Germany) has one-inch measuring range, 0.001-in. graduations

and vernier reading to 0.0001 in. Adjustment for wear or thread play can be made with a small spanner wrench supplied with each micrometer. Among features: Hardened and precision ground thread sections; glass-hard alloy steel anvil and spindle are ground and lapped and have measuring surfaces of 0.268 in. diameter.—*Techno Exports*, 15 *Whitehall St., New York* 4, *N. Y.*

Mention No. 1179 when filling out card.

Optical Level

New Optical Level for measuring flatness, straightness and parallelism reads deviations from horizontal of 0.00012 inch per foot of length or 100 microinches per inch of length. There is no limit to length of work that can be checked by moving instrument along a surface 7 in. at a time (or in shorter



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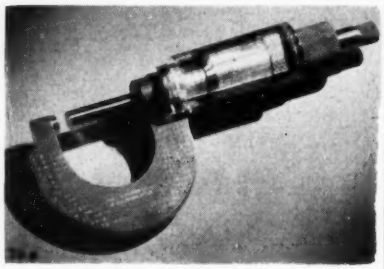
increments) and by taking a series of readings. Optical system consists of three bubble phials and two prisms so arranged that twice usual accuracy of level reading is obtained and an exact reference is observed. Amount and value of deviation from true horizontal in workpiece being examined are measured by means of a large-diameter micrometer thimble and barrel with easily-read graduations.—*F. T. Griswold Mfg. Co., W. Lancaster Ave., Wayne, Penna.*

Mention No. 1180 when filling out card.

Micrometer Magnifier

New model of "Magna Eye" for micrometers has improvements in location of 5 beads inside collar, to assure proper fitting to micrometer, especially



those with full-finished frames. Another improvement is change in curvature of magnifying part, which makes easier, quicker and more accurate reading.—*Stebar Co.*, 711 *W. Lake St., Minneapolis* 8, *Minn.*

Mention No. 1181 when filling out card.

Instrument Soldering Iron

New "No. P-25" 25-watt soldering iron weighs 3 oz. (less cord); has nickel-chromium mica-wound mounted elements; is designed for constant-duty

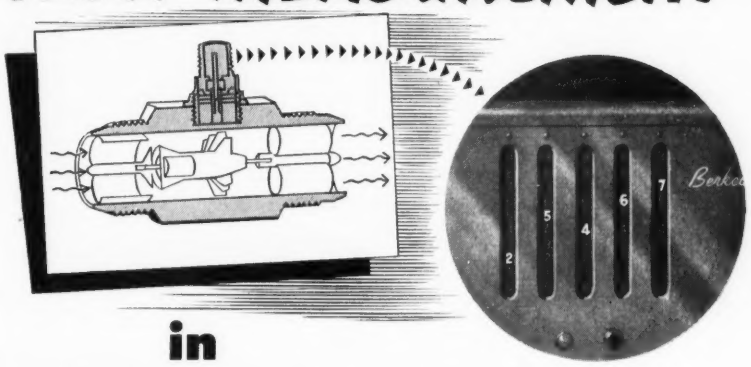
use on fast production lines. Elements, tips and other parts readily replaced by user.—*Hexacon Electric Co.*, 180 *W. Clay Ave., Roselle Park, N. J.*

Mention No. 1182 when filling out card.

Lathe Microscope

New instrument-maker's microscope can be attached to any make of jeweler's lathe, provides fixed magnification of either 20X or 40X; is available with or without a reticle; swings out of work's way without losing focusing adjustment. Flexibility of adjustment allows wide field to take in all work area. Fine focusing by means of rack-and-

FLOW MEASUREMENT



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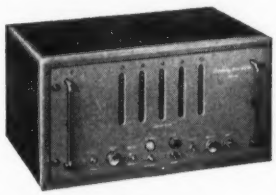
RAPID, ACCURATE determination of rate of flow of volatile or explosive fluids in high-pressure systems is provided by the Berkeley EPUT (Events-Per-Unit-Time) Meter in conjunction with magnetic flowmeter mounted in the fluid line. Rotation of the flowmeter impeller produces electrical pulses at a frequency directly proportional to rate of flow. These impulses are counted by the EPUT during a precise predetermined time interval and the results are displayed in direct-reading digital form on the illuminated front panel. The unit may be recycled either manually or automatically. Remote indication, maximum safety, accuracy of measurement and ease of operation are important features of this system.



MODIFICATIONS: Variable presettable time base can be provided for direct indication of rate of flow in the desired units of measurement. The entire equipment can be supplied in explosion-proof housings if required.

APPLICATIONS: Fuel consumption measurements in engine and gas-turbine test cells; precise flow measurement for accurate control in chemical, petro-chemical and general industrial research and manufacture.

SPECIFICATIONS

	MODEL 554	MODEL 556
RANGE	20-100,000 cps	20-100,000 cps.
ACCURACY	± 1 cycle	Line voltage stability (approx. 0.1%)
TIME BASE	1 second	1 second
SHORT TERM STABILITY	Standard crystal—1 part in 10^5 Oven crystal—1 part in 10^6	Line voltage stability
POWER REQUIREMENTS	105v.-130v., 60c., 175w.	105v.-130v., 60c., 125w.
INPUT (any wave form)	0.2-50 volts rms (pos.)	0.2-50 volts, rms (pos.)
DISPLAY	Direct reading digital—variable 1-5 seconds	
DIMENSIONS	20¾" x 10½" x 15"	16⅝" x 10¼" x 12⅞"
PANEL	Standard rack 19" x 8¾"	15⅜" x 8¾"
PRICE	$775	$560

This is one of many broad applications wherein Berkeley instruments can provide direct reading digital presentation of information at extremely high orders of accuracy.

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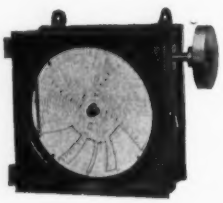

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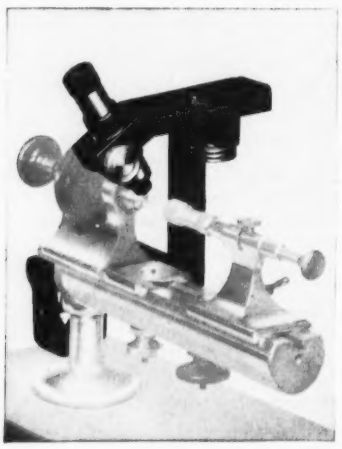
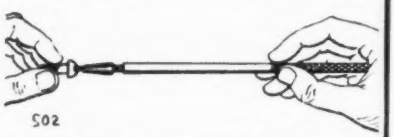


pinion. Cast aluminum body deadens lathe vibration. — *Pacific Transducer Corp. (formerly Clarkstan Corp.), 11921 West Pico Boulevard, Los Angeles 64, Calif.*

Mention No. 1183 when filling out card.

Screw-holding Screwdriver

New screw-holding screwdriver has twin bits that expand to grip screw while user places screw and starts

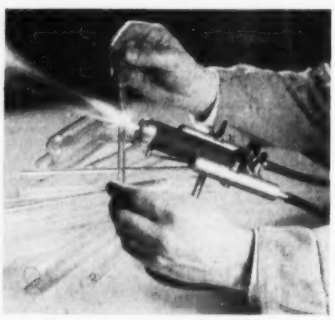


threads. Bits release screw when user withdraws driver. To prepare for next screw, user taps end. New tool is available in various lengths, blade widths and blade thicknesses.—*The H. J. J. Company, 268 Marlow Ave., Oakland 5, Calif.*

Mention No. 1184 when filling out card.

Glassblowers' Burners

New models of "Fisher-Todd Blast Burners" operate almost silently because of pre-mixing of gases within



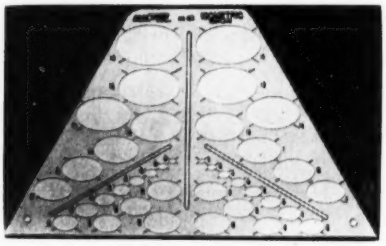
burner before external combustion. One-piece gas and oxygen entering chambers minimize danger of leaks. Any one of four basic working flames (small or large sealing flames, small or large annealing flames) may be had as a bushy, luminous, or pointed flame. Two models:

"Standard Blast" furnishes sufficiently high temperatures to work glass tubing up to 2 in. diameter; has dual gas control valves for inner and outer burners and a single oxygen control valve. "Master Blast," for either occasional or professional glassblowers, is more powerful, is in reality two completely independent burners built concentrically into the same burner body. Both models are available in a "Type A" (for gases having 300 to 1500 Btu's per cubic foot) and a "Type B" (1500 to 2500 Btu cf.).—*Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.*

Mention No. 1185 when filling out card.

Ellipse Template

New "No. 123 Isometric Template" contains 38 ellipses; features a slot arrangement whereby all three axes can be drawn without turning template (except when ellipses in a different ele-

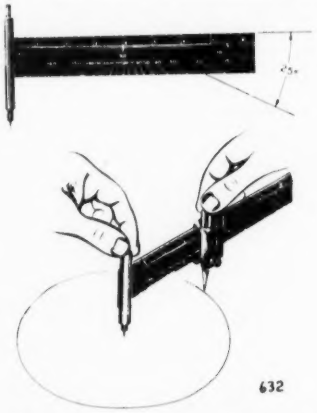


vation are required). Template is made of 0.040 mathematical-quality plastic. Axes and sizes are indelibly printed. All cut-outs are machine milled.—*Rapidesign, Inc., P. O. Box 592, Glendale, Calif.*

Mention No. 1186 when filling out card.

Combination Compass

New versatile drawing instrument can be used as a compass to make circles up to 15 in. diam., as an 8.5 in. scale (graduated in sixteenths), as a



straight edge, as a protractor, as a T-square, and as a marking gage. A knurled nut locks in pencil (all standard sizes) and slider.—*Dept. 45, Ambi Corp., Box 39, Whitestone, N. Y.*

Mention No. 1187 when filling out card.

Flame Failure Safeguard

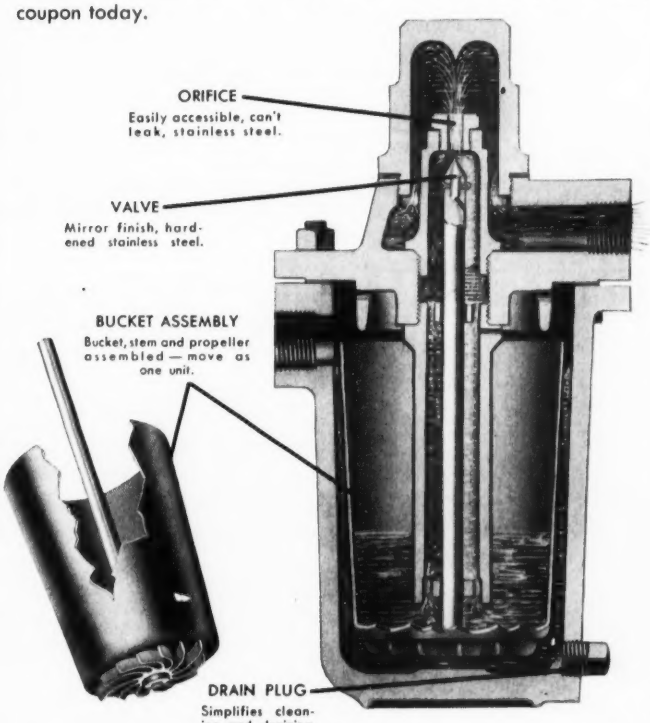
New "Fireye Type F18T-3 Flame Failure Safeguard" provides operating flame failure protection for manually-

KEEP UPKEEP DOWN

no wire drawing with a TRERICE trap!

Wire drawing—a bugaboo for most traps—has been practically eliminated by the rotating valve feature of a Trerice trap. Bucket, valve stem and propeller—assembled as one unit—comprise the only moving part. Water action rotates the propeller causing the valve to seat differently in the orifice at each discharge. As a result, there's even wear all way 'round. Remember, too, you can completely inspect or service the valve and seat in a Trerice trap in a matter of minutes—without removing it from the line or disturbing high pressure bolts.

But—see for yourself! We'll be glad to provide a 60-day trial installation under your own conditions and without obligation. Send coupon today.



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Yes, I want to try the Trerice "Rotating Valve" trap for 60 days.
Trap Size _____ Pressure _____
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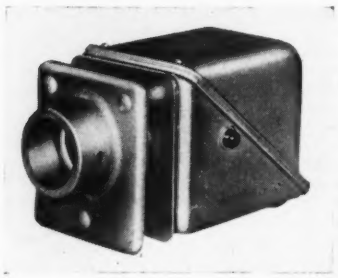


ignited oil burners; is used with programming controls to protect automatically-ignited oil burner installations; is approved by all leading insurance laboratories. A hermetically-sealed time-delay element prevents flame relay from dropping out from purely transient disturbances.—*Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.*

Mention No. 1188 when filling out card.

Air-cooled Flame-rectifier Head and Chuck Adapter

New air-cooled flame rectifier head is for use on applications where temperatures around furnace walls are more than 1300 F. A companion device, a chuck adapter, is for changing any Honeywell insulator-type flame head to a right-angle electrode holder. Rectifier head is also for use when a positive pressure inside a burner tends to force out heat around head and chuck. Basic unit consists of head, air-tight electrical connector, 8-in. stainless steel rod and chuck assembly, and an outside pipe support and insulator.—*Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

Mention No. 1189 when filling out card.

Liquid Level Controller

New "Type 10CB1 Liquid Level Control" is recommended for level control of all electrically-conductive liquids.

Selection from four sensitivity ranges permits matching probe circuit to electrical resistivity of liquid being controlled. Control will discriminate between a liquid and its foam (important in handling dairy products); is not affected by saturated vapor above liquid in a closed tank (permitting positive control of acid in batch processing).—*Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.*

Mention No. 1190 when filling out card.

Gas Washing Apparatus

New "No. 5506" Gas Washing Apparatus offers advantages over conventional type bottle and stopper arrangement: (1) requires small volumes of absorbing solution; (2) gas passes through 15-16 liquid exchanges; (3) small pressure drop; (4) unit lends itself well to rapid circulation of scrubber solution as it passes up through indented tubes; (5) plugging due to crystallization of salts in gas inlet tube is completely eliminated; (6) heat generated by chemical reaction of gas with absorber solution is more rapidly dissipated than with conventional scrubber.—*Ace Glass Inc., Vineland, N. J.*

Mention No. 1191 when filling out card.

Laboratory Water Baths

New utility and serological water baths are said to offer a number of exclusive features. Polished 18-8 stainless steel interiors and exteriors; special thermostat range from room to 100 C.; sensitivity and uniformity better than 0.5 deg. at any point to 100 C.; heat diffuser plate eliminates "hot spots"; 1-in. insulation.—*Labline, Inc., 217 N. Desplaines St., Chicago 6, Ill.*

Mention No. 1192 when filling out card.

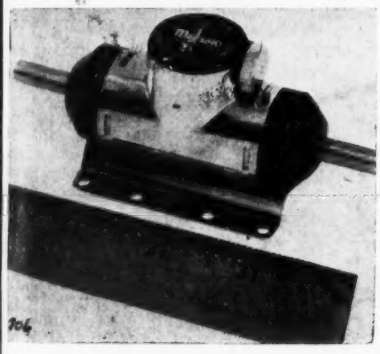
Laboratory Sink

New steel sink unit, providing needed flexibility for any type of laboratory planning, has a heavy-duty laboratory double faucet of solid brass, triple-plated with copper, nickel and chrome. Trap, overflow and outlet plug are tellurium lead. Basin is made of "Chemstone" and features a leak-proof tongue-and-groove and cement-bonded construction. Three sizes: 16-, 37-, and 47-in., all 16 in. wide and 9 in. deep. New sink is one of units in maker's complete line of matched metal sectional laboratory furniture comprising 17 basic units that fit flush with one another.—*Emil Greiner Co., 20-26 N. Moore St., New York, N. Y.*

Mention No. 1193 when filling out card.

Miniature Adjustable Speed Changer

New "Type 3A Variable Speed Changer" weighs less than 6 oz. All speeds are selected smoothly and quickly, whether unit is running or stopped. Speed is controlled by an adjusting knob equipped with friction drag to prevent ratio wander. In addition, lever,



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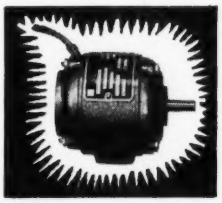

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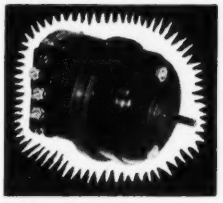

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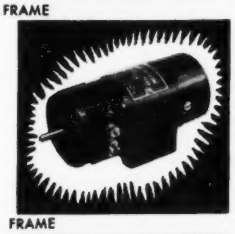

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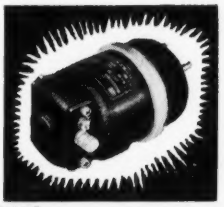

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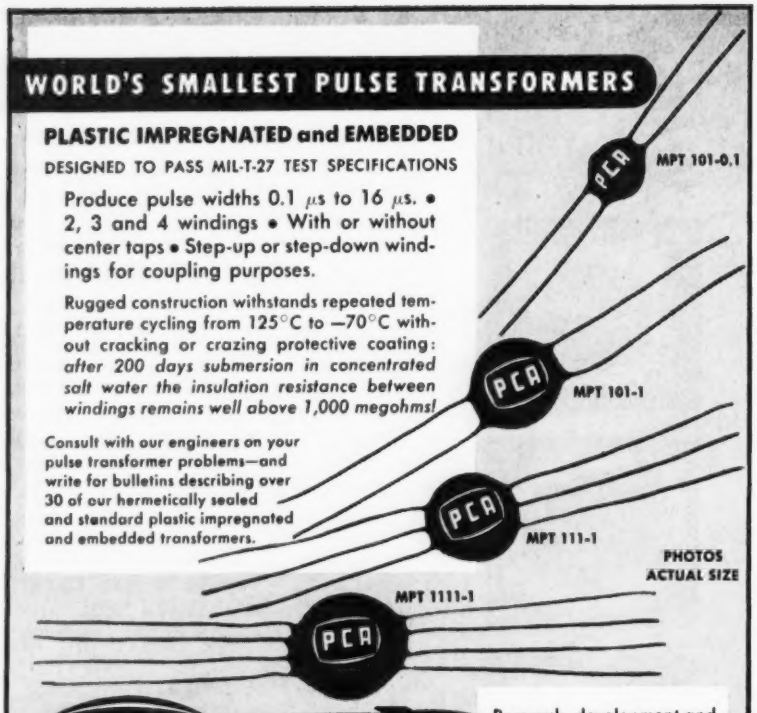

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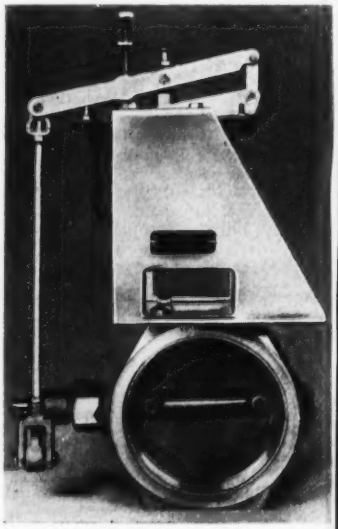
NEW INSTRUMENTS

push-rod, spur-gear, miter-gear and worm-gear speed controls are available. Pointer-and-dial on top of unit indicates speed ratio.—*Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.*

Mention No. 1194 when filling out card.

Butterfly Control Valve

New "Grad-U-Motor" pneumatically operated butterfly valve for control of air, water or steam flow operates on



0-15-psi controlled air pressure range. Adjustable mechanical stops on motor enable wing rotation to be limited for special applications. Valve sizes from 1.5 to 6 inches; screwed connections; bronze body, wing and trim; maximum pressure, 20 psi.—*Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

Mention No. 1195 when filling out card.

Solenoid Shut-off Valve with Time Delay Feature

New midget solenoid shut-off valve has time delay mechanism which holds back flow of liquid or gas through valve

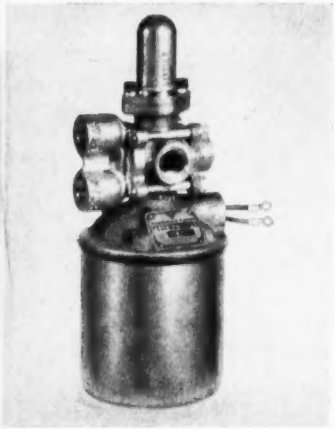
for about 5.5 seconds after solenoid becomes energized. In oil-burner applications where desirable to have instant combustion, delay mechanism holds back flow of oil until a full stream of air flows through burner. On subse

quent stoppage and re-lighting, delay gives sufficient time to purge fire box of old fumes and smoke. Shut-off is instantaneous and positive. A similar 2-way valve with time delay feature is available.—*Automatic Switch Co., 79-D Lakeside Ave., Orange, N. J.*

Mention No. 1196 when filling out card.

Solenoid Valves

New line of "Shear-Seal" solenoid valves comprises shut-off, 2-way diverter, 3-way selector, and 4-way selector.

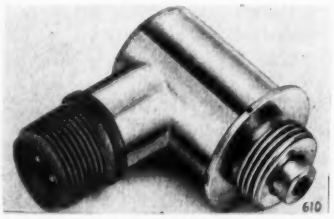


Valves for air, water, and oil service come in three groups of pressure ranges: 0 to 250 psi., 0 to 1500 psi., and 0 to 3000 psi.—*Barksdale Valves, 1566 East Slauson Ave., Los Angeles 11, Calif.*

Mention No. 1197 when filling out card.

Miniature Solenoid

New miniature side-mounted connector solenoid has over-all height of 1.375 in. and weights 0.29 lb.; exerts

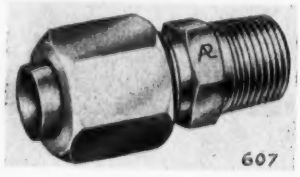


2 lbs. pull at 0.125-in. stroke at 18 volts d.c.; is satisfactory for use in ambient temps. to 300 F.; is designed to MIL 4040 specs.—*Engineering Div., Lafayette Eng. & Dev. Co., 9675 Santa Monica Blvd., Beverly Hills, Calif.*

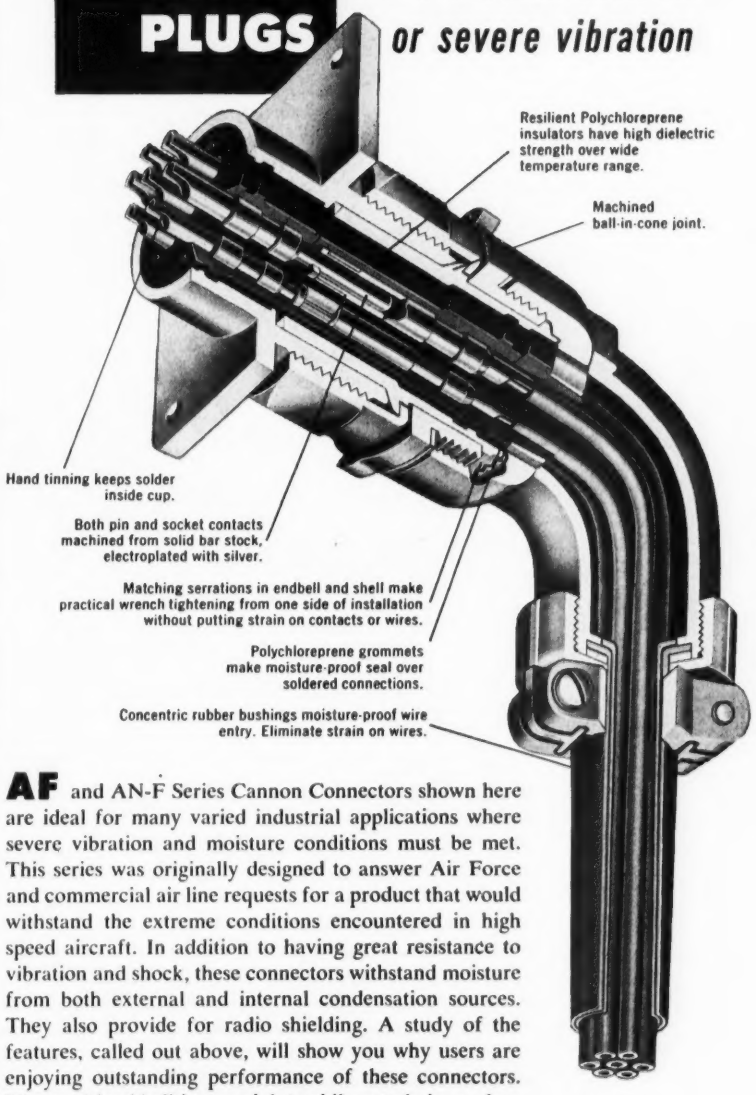
Mention No. 1198 when filling out card.

Aluminum Tube Fittings

New standard-stock line of aluminum tube fittings, for strictly industrial applications rather than aircraft use, in-



CANNON PLUGS *to withstand moisture or severe vibration*


Resilient Polychloreprene insulators have high dielectric strength over wide temperature range.
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Hand tinning keeps solder inside cup.
Both pin and socket contacts machined from solid bar stock, electroplated with silver.
Matching serrations in endbell and shell make practical wrench tightening from one side of installation without putting strain on contacts or wires.
Polychloreprene grommets make moisture-proof seal over soldered connections.
Concentric rubber bushings moisture-proof wire entry. Eliminate strain on wires.

AF and AN-F Series Cannon Connectors shown here are ideal for many varied industrial applications where severe vibration and moisture conditions must be met. This series was originally designed to answer Air Force and commercial air line requests for a product that would withstand the extreme conditions encountered in high speed aircraft. In addition to having great resistance to vibration and shock, these connectors withstand moisture from both external and internal condensation sources. They also provide for radio shielding. A study of the features, called out above, will show you why users are enjoying outstanding performance of these connectors. The machined ball-in-cone joint, while not obvious, plays an important part in providing radio shielding and improved vibration and moisture resistance. For engineering data request Cannon's AN Bulletin.

The Cannon AF Series consists of 2 plug types and 3 receptacles in 15 diameters. Contact arrangements closely follow those in the AN Series. Shells are cadmium plated. The sturdy hex shaped coupling nut shown here is used on sizes 8S through 18. Larger diameters have a strong spline type coupling nut to fit spanner wrenches. Knurled type coupling nuts are available to meet AN-F specification.

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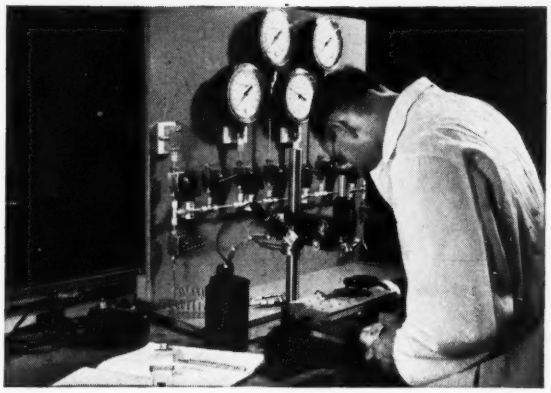

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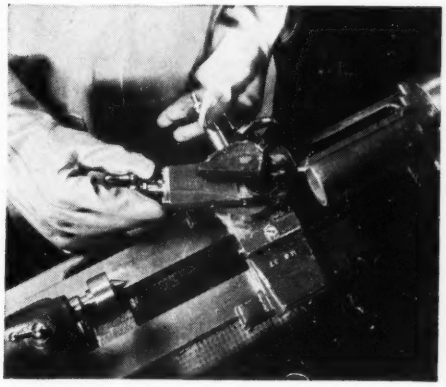

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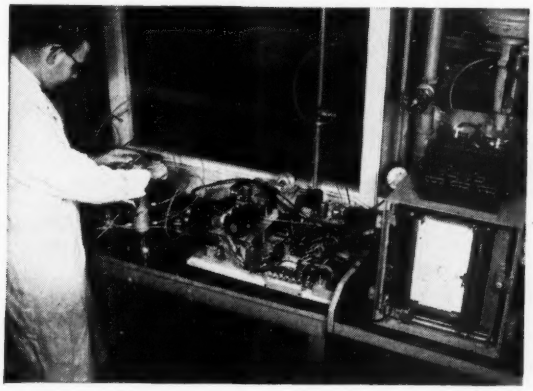

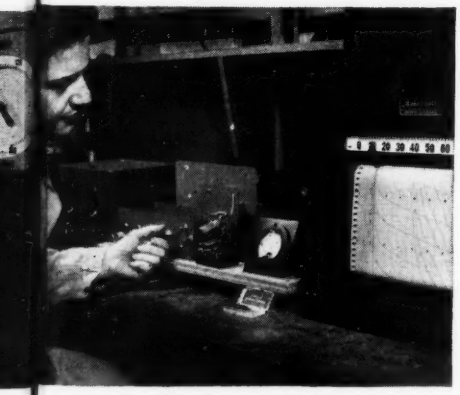

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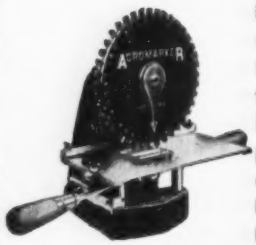

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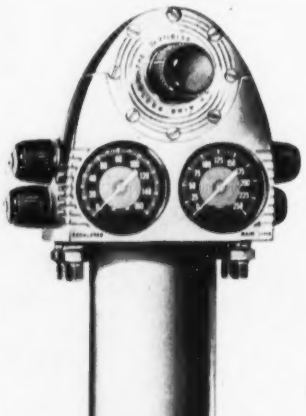
NEW INSTRUMENTS

cludes male and female connectors, elbows, tees, union and tube end reducer for 0.25, 0.3125, 0.375 and 0.5 in. OD tubing; is provided in maker's "Triple-lok" design—*The Parker Appliance Co.*, 17325 *Euclid Ave., Cleveland* 10, *Ohio.*

Mention No. 1199 when filling out card.

Air Regulator and Cleaner

New "HLD Air Transformer" has a built-in two-stage pressure regulator: finger-tip control of adjusting knob



actuates a small pilot regulator which in turn operates diaphragm of large regulator. Two regulated air outlets and two unregulated. Capacity 100 cfm. Oil and moisture captured in condenser tube easily drained.—*DeVilbiss Co.*, 296 *Phillips Ave., Toledo* 1, *Ohio.*

Mention No. 1200 when filling out card.

Air Flow Snubber

New air flow snubber and pulsation damper provides a controlled slow rate of flow of compressed air or gas for

operation of continuous-reading hydrostatic instruments and for purging pneumatic instrument lines; protects pneumatic testing and gaging equip-

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ment against surge-pressure damage; serves as pulsation damper for pressure gages, recorders, manometers, etc. Snubbing action is accomplished by passing the air or gas through a helical restriction (nearly 7 in. long) formed by screw threads. Should restriction be plugged by dirt or moisture, snubbing screw is removed and cleaned without disconnecting snubber. Flow rate approx. 0.04 cfm. at 70-psi. pressure drop; maximum operating pressure 1,000 psi. —*King Engineering Corp., Box 530, Ann Arbor, Mich.*

Mention No. 1201 when filling out card.

Diaphragm-motor for Valves

New pneumatic diaphragm-motor valve operator, for use on any of maker's N-O, N-C, 3-way or slide valve, is adaptable for manual or automatic control systems. Mounting space is provided for control instruments and "Type V-301 and V-302" pneumatic pressure regulators. Operators are available in 13- and 16-in. diaphragm sizes; other sizes on special order.—*General Controls Co., 801 Allen Ave., Glendale 1, Calif.*

Mention No. 1202 when filling out card.

Control Valve for Sub-zero Temperatures

New "Hydramotor" valve opens fully in one minute even at temperatures of minus 65 F.; will be available in sizes up to 6 in. with pressure ratings from 2-in. at 600 psi. to 6-in. at 65 psi.; for any flowing medium; "in remote or manually controlled models." In event of current failure, even in extreme cold, valve will resume operation within 15 minutes after resumption of electric power.—*General Controls Co., 801 Allen Ave., Glendale 1, Calif.*

Mention No. 1203 when filling out card.

Needle Valve

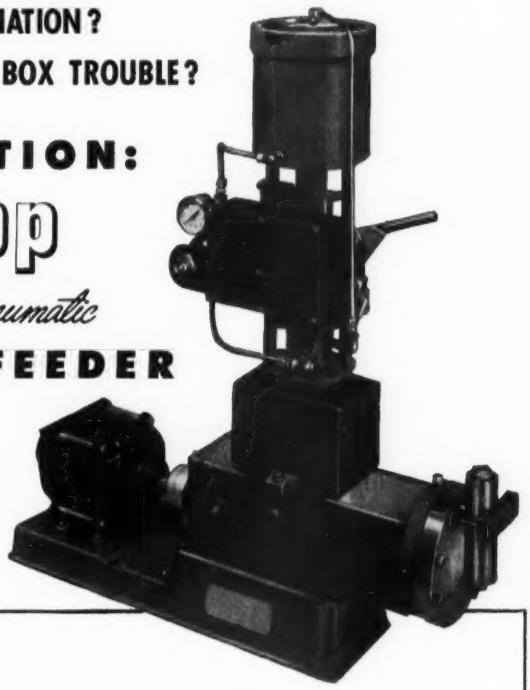
New forged-steel-body needle valve, designed for high-presure service, has threads regulating stem travel machined in body, not in bonnet. Bonnet has unusually deep packing space, functions only as stem guide and packing reservoir, has no relation to stem travel. Thus, stem in closed position provides positive fluid shut-off with bonnet entirely removed from body. In addition to forged steel bodies, carbon steel, Monel

PROBLEM:

PUMPING CORROSIVE CHEMICALS?
POSITIVE, AUTOMATICALLY-REGULATED FEED?
CONTAMINATION?
STUFFING BOX TROUBLE?

SOLUTION:

Lapp
Auto-Pneumatic
PULSAFEEDER



Chemicals successfully being handled include gum and sludge inhibitors, metal deactivators, anti-oxidants, dyes and stabilizers. Also those for boiler water or processing water treatment—concentrated sulphuric acid, sodium sulphite, filter aid slurries, liquid caustic. For the Lapp Pulsafeeder is the positive-displacement pump for controlled-volume pumping of liquids which depends on no stuffing box or running seal—avoids contamination by an hydraulically-balanced diaphragm which isolates pumping mechanism from chemical being handled. Pumps against pressures up to 2,000 lbs., at constant pumping speed—variable flow results from variation only in piston-stroke length. Auto-Pneumatic control uses instrument air pressure responding to any instrument-measurable variable.

GOT A SPECIAL PROBLEM? Every month we hear about applications to which the Lapp Pulsafeeder is the long-awaited answer. A newly-issued bulletin, No. 300, will tell you about our pump and its characteristics, with typical applications and flow charts. A Pulsafeeder Inquiry Data Sheet, on which you can outline your processing requirement, will bring an engineering recommendation. Write us today. Lapp Insulator Co., Inc., Process Equipment Division, 572 Maple Street, Le Roy, N. Y.

Lapp
Auto-Pneumatic
PULSAFEEDER

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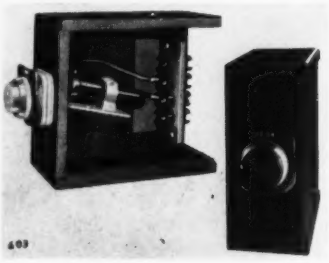
NEW INSTRUMENTS

and various types of stainless steel are available. Valve can be provided in regular style or in panel mounting.—*Dragon Engineering Co.*, 5817 *South Central Ave., Los Angeles* 11, *Calif.*

Mention No. 1204 when filling out card.

Mercury Safety Switch

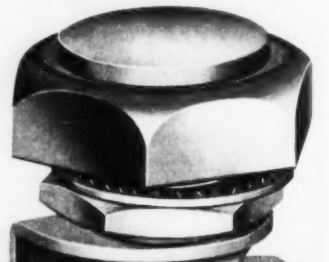
New mercury switch, for positive safety in hazardous explosive locations, comprises a hermetically-sealed mercury switch mounted on a lever-operated armature and actuated by a selector knob or push button which inclines armature. (No possibility of a spark, because of all-mechanical nature of actuating linkage.) Designed for vertical panel mounting, new mercury switch is s-p.s-t. or s-p.d-t. All push-button models have spring action which returns switch to original position when finger pressure is released.—*Tigerman Engineering Co.*, 4332 *North Clark St., Chicago* 26, *Ill.*



Mention No. 1205 when filling out card.

Small Weatherproof Switch

New d-p.d-t. weather- and oil-proof push-button electric switch weighs 1 oz.; Underwriters' Laboratories ratings: 250 v.a.c., 5 amp; 30 v.dc. inductive loads 2 amps. at sea level and 1.5 amps. at 50,000 feet.—*Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.*



Mention No. 1206 when filling out card.

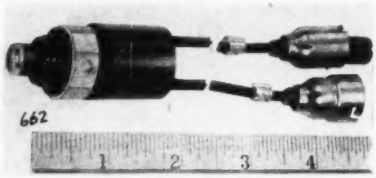
Small Toggle Switches

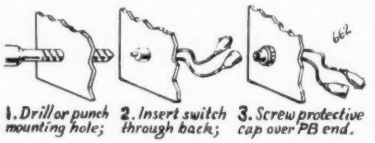
New series of extremely small toggle switches, primarily for aircraft use but also with industrial applications, include s-p.d-t. and d-p.d-t. models.—*Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.*

Mention No. 1207 when filling out card.

Waterproofed P-b. Switch

New waterproofed push button switch is said to function perfectly from minus 65 F. to 165 F. and to withstand salt spray, shock and vibration. Switch is s-t., either n-o. or n-c.; continuous rating 10 amps., 30 volts d.c., or 125 volts a.c.—*Riverside Mfg. & Electrical Supply Co.*, 10228 *Michigan Ave., Dearborn, Mich.*





Mention No. 1208 when filling out card.

Motor-actuated Coaxial Switch

New "Model CA-26" r-f. coaxial switch is actuated by a 115-volt 60-cycle a-c. motor; meets ground military performance specifications. At frequencies to 10,750 Mc. it has a maximum VSWR of 1.5 and 0.2 db insertion loss. At 3,000 Mc., crosstalk is in excess of

55 db. Power rating 100 watts continuous cw at 3,000 Mc.; actuation time less than 1 second.–*Electronics Div., Thompson Products, Inc., 2196 Clarkwood Road, Cleveland 3, Ohio.*

Mention No. 1209 when filling out card.

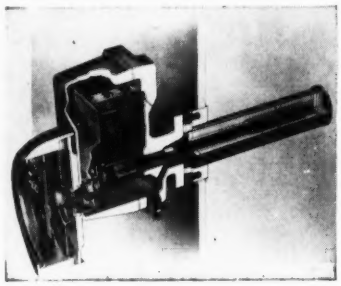
Switch Kits

New "414" and "419" switch kits contain maker's latest switch parts in 17-in.-wide metal cabinet designed to fit standard steel shelving. "414" kit contains 111 phenolic switch sections, 31 index assemblies, and complete hardware, brackets, knobs, and dial plates. "419" kit contains 81 steatite-ceramic switch sections, 27 index assemblies, complete hardware, etc.—*Centralab Div., Globe Union Inc., Milwaukee 1, Wis.*

Mention No. 1210 when filling out card.

Thermal Overload Relay

New "Type TRO" thermal overload relay for power transformers has indicating dial calibrated in "percent



thermal load": 100-percent mark corresponds to "signal" position of relay; 110-percent mark to "trip" point of relay. A maximum-indicating hand remains in position of greatest deflection of indicating pointer, can be reset manually from ground level.—*Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.*

Mention No. 1211 when filling out card.

Alarm-silencing Relay

New alarm-silencing relay is automatically reset; provides added safety because it often happens that after a condition that caused an alarm has been corrected, a worker forgets to close a switch or push a reset button, causing alarm to become inoperative. On new relay, a red pilot light warns unit alarm circuit has been cleared: when controller switch makes contact, alarm and pilot light are energized; when operator pushes a button on front of relay, alarm is stopped but pilot light remains energized; light will go out when improper condition is corrected and relay is then ready for next cycle.—*Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

Mention No. 1212 when filling out card.

Plugs and Jacks

New "No. 440 Littel Plug" (PJ-055B) features a one-piece tip rod assembled with its sleeve into mold as an insert; whence complete continuity of thermoplastic insulation. Meets specifications JAN-P-642. Mates with such

This new Bendix-Pacific development is an extremely compact and very lightweight S-band beacon. It is designed for use in aircraft and guided missiles, to increase the operating range of the tracking radar by reinforcing the normal echo with a retransmitted signal.

Despite its minimum size, the beacon has been fully engineered to withstand the shock, vibration, and temperature conditions encountered in missile installations.

SPECIFICATIONS:

Sensitivity: —40 dbm signal for steady triggering

Output: Power: 50 peak watts nominal
Frequency: 2700-2900 mc.

Pulse Width: .6 microseconds to 3 db points
Repetition Rate of Interrogator: 200-2500 pps.

Power Requirements: 6.3 volts AC or DC ±10% at 4.0 amps.
300 volts DC nominal at approx. 120 ma.

Controls: Accessible through end of case. Cavity frequency control. Sensitivity control.

Stability: Frequency drift less than 3 mc.

Delay Time: Delay between received and transmitted pulses approximately 1.5 microseconds.

Environmental Conditions: Acceleration of 55 G's on longitudinal axis for 5 seconds.
Vibration of .06 in. total amplitude at 50 cps for 3 minutes.
Shock of 30 G's for 11 milliseconds in any plane.
Pressure sealed for high altitude operation.
Requires no forced air cooling for continuous operation between —55° C (—67° F) and 38° C (100° F).

Size: 3½ dia. x 12 in. long exclusive of connectors.

Weight: 5.5 lbs.

In addition to the S-band beacon Bendix-Pacific can supply similar equipment to cover the X-band, or to answer only a definite coded interrogation.

Complete engineering assistance is also available for other types of beacons to meet any specific requirement. Complete information will be sent to qualified companies.

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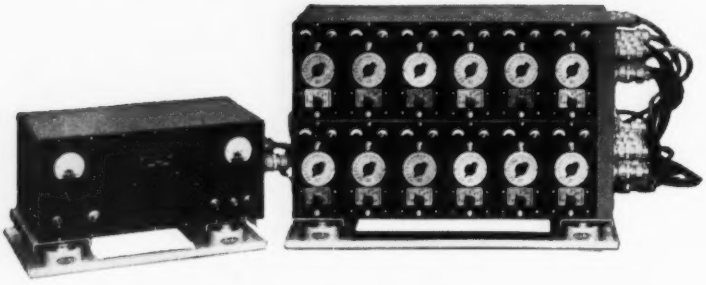
Century VIBRATION AND STRESS ANALYSIS SYSTEM



The Century Vibration and Stress Analysis System provides all of the necessary equipment to amplify and record vibration and stress-strain phenomena over a frequency range from 0 to 2000 cps.

Two modes of measurements are used in covering this system: (a) a carrier amplifier system to measure phenomena in the range of 0-500 cps, utilizing externally excited pick-ups as the sensing element; and (b) a linear-integrating amplifier system covering the range of 3-2000 cps, utilizing self-generating pick-ups, or d.c. excited strain gages employed dynamically. Both of these modes utilize either the Century Model 408 or 409 Oscillograph.

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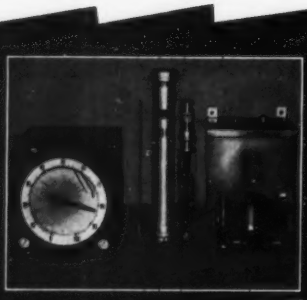

GAGETRON Applied to Measurement of Catalyst Level

New industrial application of atomic energy employs radium and hydrogen tube. Catalyst level is measured by number of atomic impulses passing through the counter tube. The primary element is the GAGETRON.

The GAGETRON is manufactured under Graham Patent No. 2,565,963.

FREE! Safety Code for use of radium. Also GAGETRON Bulletin No. 149.

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NEW INSTRUMENTS

standard jacks as JAN type JJ-034. New "No. 820 Extension Jax" (JJ-026) features spring-tempered nickel-silver springs assembled into a rigid stack assembly. Meets specifications JAN-J-641. Mates with plug types PJ-054 and J-540.—*Switchcraft, Inc., 1328 N. Halsted St., Chicago 22, Ill.*

Mention No. 1213 when filling out card.

VTVM Test Leads

New test leads are designed to fit vacuum-tube voltmeters equipped with screw-on microphone type connectors. "No. 316" contains an isolating resistor in its probe and is intended for d-c measurements; "No. 317" is a straight-through lead for utility applications. Both are 6 ft. long, are made of heavy shielded wire, have insulated handles.—*Insuline Corporation of America, 36-02 35th Avenue, Long Island City, N. Y.*

Mention No. 1214 when filling out card.

Heavy-duty Connectors

New "Series AO" heavy-duty plugs and receptacles, based on US Army Ordnance specification, are suitable for military vehicles and for industrial and

other applications under extreme conditions of moisture, dust, vibration and shock. Six sizes currently tooled include 12, 14S, 16, 22, 28.—*Cannon Electric Co., P. O. Box 75, Lincoln Heights Station, Los Angeles 31, Calif.*

Mention No. 1215 when filling out card.

Discharge Capacitor

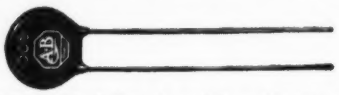
New "DA778-001" ultra-high-speed discharge capacitor, physically a tube 2 in. diam. and 6.5 in. long, has characteristics of 30 ft. of solid coaxial transmission cable. When used in same manner as coaxial cable, charged to 10,000 volts and discharged across a spark gap, capacitor tube improves light intensity 900 times. Tube is made of hi-K ceramic (K-2000), silvered inside and out; has capacitance rating of at least 0.024 mfd. (24,000 mmf.) and immersed in

transformer oil is rated at a working voltage of 20,000 volts d.c. Decay time, peak to peak, 2×10^{-7} second; rise time, zero to peak, 2×10^{-7} second; and 50 percent of peak limits occur in 1.8×10^{-7} second. Leakage resistance in excess of 10,000 megohms; dielectric strength approx. 35 volts per mil.—*Centralab Div., Globe-Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.*

Mention No. 1216 when filling out card.

Ceramic Capacitors

New line of disk type ceramic capacitors range from 0.001 to 0.01 microfarads. Basic element is a ceramic disk

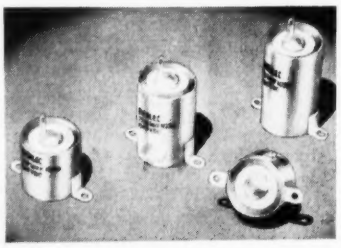


of high K dielectric, with a deposit of silver paste applied to each face and heat treated to reduce to metallic silver. —*Allen-Bradley Co., Milwaukee, Wis.*

Mention No. 1217 when filling out card.

Sealed Ceramic Capacitors

New "Type B20, B21, B22, and B23" precision metal-encased tubular ceramic capacitors extend capacitance range at rated voltages of 500, 1000, and 1500



v.d.c. Capacitance tolerance within 1 percent and temperature coefficient tolerances within 10 ppm. per deg. C. are possible.—*Sprague Electric Co., 43 Marshall St., North Adams, Mass.*

Mention No. 1218 when filling out card.

Glassware Clamps

New "Varigrip" stainless-steel clamp is always rigid, employs no chains or other accessories, is quickly adjusted

with a large flat thumbscrew; is said to be ideal combination handle and clamp.—*Labline, Inc., 219 North Desplaines St., Chicago 6, Ill.*

Mention No. 1219 when filling out card.

VHF Amplifier Tube

New "Type 6146" VHF beam power amplifier, intended for service as r-f. power amplifier and oscillator as well as a-f. power amplifier and modulator,

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G meter

Type 192-A

MEASURES:

- Conductance values of low loss dielectric materials.
- Q of small high quality capacitors.
- Capacitance of dielectric materials and capacitors.
- RF resistance of large value resistors.
- Dynamic impedance of resonant circuits.

The G Meter may be used to obtain values of dielectric constant and power factor of test samples to the degree of refinement required in standard testing methods such as ASTM specification D-150-47T. Test samples with very small losses and capacitances may be accurately measured. The instrument is entirely self-contained.

The G Meter employs a crystal controlled oscillator to supply voltage to a reference tuned circuit. By substituting calibrated internal parameters, the conductance and capacitance of the unknown are determined.

SPECIFICATIONS

CONDUCTANCE RANGE: 0 to 35 micromhos—Direct reading in seven ranges.

CAPICITANCE RANGE: 0 to 100 micro-micro-farads — Direct reading. (Simple indirect method allows measurements to 1000 mmf.)

FREQUENCIES: 1 mc. and 30 mc. crystal controlled.

SENSITIVITY: 10% Deflection of Panel Meter results from conductance change of 0.003 micromhos at 1 mc. and 0.03 micromhos of 30 mc.

VOLTAGE ON TEST SAMPLE: 20 to 35 volts RMS.

LINE VOLTAGE: Internal regulation permits operation over range of 105-125 volts.

PRICE: $1875.00 (either 1mc or 30 mc).

Additional Plug-In Oscillators (1mc or 30 mc) $105.00 each F.O.B. Factory

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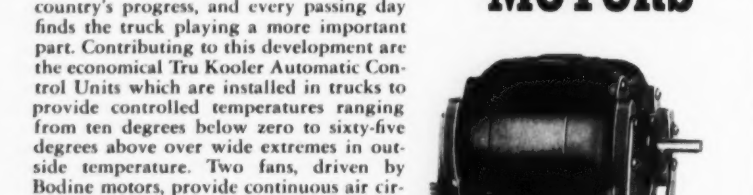
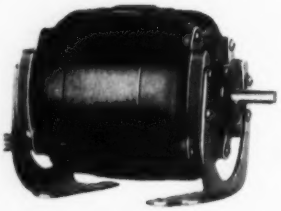


Transportation is the backbone of our country's progress, and every passing day finds the truck playing a more important part. Contributing to this development are the economical Tru Kooler Automatic Control Units which are installed in trucks to provide controlled temperatures ranging from ten degrees below zero to sixty-five degrees above over wide extremes in outside temperature. Two fans, driven by Bodine motors, provide continuous air circulation.

"Our requirements are for motors," state Tru Kooler Inc., "that will withstand abusive vibration and impact shock, spasmodic overloading, fluctuating voltage, sudden extremes in ambient temperature, long periods of operation with no maintenance, and compactness of design. Your motor has answered these problems with a maximum of dependability and life expectancy."

If you have a fractional horsepower motor application problem, it will pay you to consult Bodine engineers.



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THE POWER BEHIND THE LEADING PRODUCTS

NEW INSTRUMENTS

has max. plate-dissipation rating of 25 watts. Can be operated in c-w. service with 90 watts input up to 60 Mc. and with 60 watts input at 175 Mc.—*Tube Dep't, Radio Corp. of America, Harrison, N. J.*

Mention No. 1220 when filling out card.

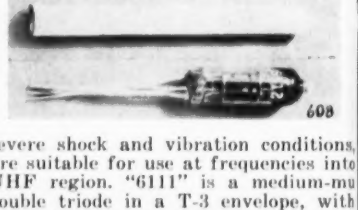
TV VD&O Tube

New "Type 6BX7GT" high-perveance double triode designed for vertical deflection and oscillator service in television receivers is particularly well suited for reduction of vertical distortion due to low plate supply voltage.—*Radio Tube Div., Sylvania Electric Products Inc.*, 1740 *Broadway, New York* 19, *N. Y.*

Mention No. 1221 when filling out card.

Subminiature Double Triodes

New "Types 6111 and 6112" subminiature double triodes, for use at relatively high ambient temperatures and



severe shock and vibration conditions, are suitable for use at frequencies into UHF region. "6111" is a medium-mu double triode in a T-3 envelope, with characteristics similar to those of "6SN7GT". "6112" is a high-mu double triode in T-3 envelope with characteristics similar to those of "6SL7GT."—*Radio Tube Div., Sylvania Electric Products Inc.*, 1740 *Broadway, New York* 19, *N. Y.*

Mention No. 1222 when filling out card.

Medium-mu Twin Triode

New "12BH7" is a medium-mu twin triode of 9-pin miniature type used in vertical deflection circuits of TV receivers; also useful in applications including multivibrators and oscillators in industrial control devices.—*Tube Dep't, Radio Corp. of America, Harrison, N. J.*

Mention No. 1223 when filling out card.

Voltage-regulator Tubes

New "6073" and "6074" are 7-pin miniature cold-cathode, glow-discharge tubes for voltage-regulator service critical as to excessive shock and vibration. They are premium versions of "OA2" and "OB2."—*Tube Dep't, Radio Corp. of America, Harrison, N. J.*

Mention No. 1224 when filling out card.

VHF Power Tetrode

New "Type 6166" forced-air-cooled power tetrode, designed for VHF service in television and CW applications, has a maximum plate dissipation of 10 kw.; is rated for operation up to 220 Mc.; utilizes a thoriated-tungsten filament.—*Tube Dep't, Radio Corporation of America, Harrison, N. J.*

Mention No. 1225 when filling out card.

Have you a copy of the Jan. 1928 *Instruments?*

If so, please notify Historical Section, Instruments Publishing Co., 921 Ridge Ave., Pittsburgh 12, Pa.

High-temperature Resistors

New precision resistors, designed for extreme high temperature applications (in excess of 235 C.), feature a low temperature coefficient resulting in nearly constant ohmic value from -55 C. to +125 C. (total change under 0.2 percent). Maximum resistances to 25,000 ohms and power ratings to 6 watts can be supplied. Standard tolerances 1 percent, special to 0.1 percent. Units are built to exceed MIL-R93 specs.—*Instrument Resistors Co., Commerce Avenue, Union, N. J.*

Mention No. 1226 when filling out card.

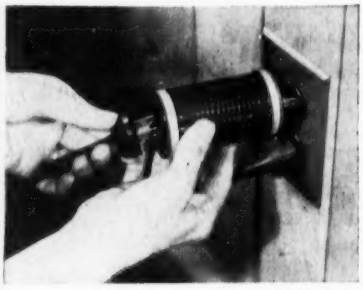
Noble-metal-film-on-glass VHF & UHF Resistor

New "Type R" is a highly stable noble-metal-film-on-glass resistor for microwave applications, said to be ideal for power measurements, resistive pick-up loops, pads, impedance matching, attenuators, in both waveguide and coax. It permits expensive microwave fittings to be replaced economically with improvement in performance.—*Telewave Laboratories, Inc., 100 Metropolitan Ave., Brooklyn, N. Y.*

Mention No. 1227 when filling out card.

TV Plug-in Ballast Resistors

New "Type TVA" (200 to 300 watts) and "Type TVB" (300 to 375 watts) are designed primarily to be plugged in



between TV set and electric receptacle, in areas where line voltage tends to increase up to 140 volts. One unit can be plugged into another, or two or more can be operated in series to obtain greater voltage drops where needed.—*Clarostat Mfg.Co., Inc., Dover, N. H.*

Mention No. 1228 when filling out card.

TV Master Antenna System

New "Super Series 2500 Tacoplex" TV master antenna distribution system features an output of 6 volts peak-to-peak; voltage gain of more than

The S.S. WHITE 80X HIGH VOLTAGE RESISTOR

(½ Actual Size)

4 watts • 100 to 100,000 megohms

Developed for use as potential dividers in high voltage electrostatic generators, S.S. White 80X Resistors have many characteristics—particularly negative temperature and voltage coefficients—which make them suitable for other high voltage applications.

They are constructed of a mixture of conducting material and binder made by a process which assures adequate mechanical strength and durability. This material is non-hygroscopic and, therefore, moisture - resistant. The resistors are also coated with General Electric Dri-film which further protects them against humidity and also stabilizes the resistors.

WRITE FOR BULLETIN 4906

It gives complete information on S.S.White resistors. A free copy and price list will be sent on request.

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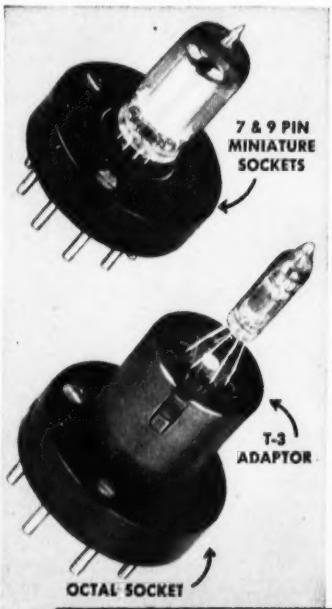

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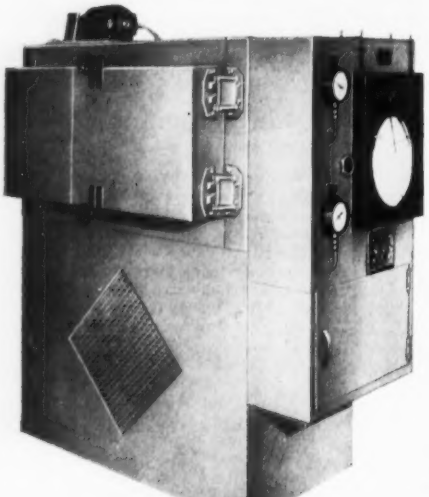

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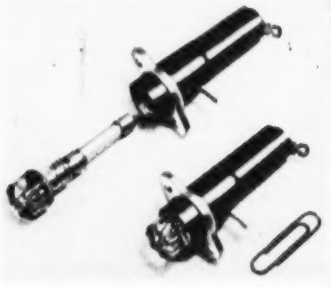

neon bulb that lights up when fuse blows.—*Alden Products Co.*, 117 N. Main St., *Brockton* 64, *Mass.*

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Plug-in Frequency Standard

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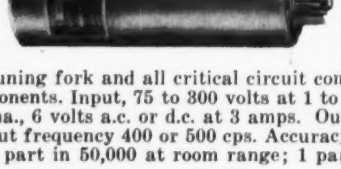

tuning fork and all critical circuit components. Input, 75 to 300 volts at 1 to 5 ma., 6 volts a.c. or d.c. at 3 amps. Output frequency 400 or 500 cps. Accuracy, 1 part in 50,000 at room range; 1 part

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INSTRUMENT EVENTS
Calendar

Sept. 22-30
Third Instruments and Measurements Conference and Exhibition, Stockholm, Sweden. For information write Mr. Yngve Axner, Kungl. Tekniska Hogspolan, Stockholm 70.

Sept. 29-Oct. 1
Eighth National Electronics Conference and Exhibition.
Sherman Hotel, Chicago.
For information write Karl Kramer, Ex. Sec., 852 E. 83rd St., Chicago 19.

Oct. 7
Society for Applied Spectroscopy, Socony-Vacuum Training Center, 63 Park Row, New York City, N. Y. For information write C. A. Jedlicka, Secretary, Lucius Pitkin, Inc., 47 Fulton St., New York 7, N. Y.

Oct. 15-16
Scientific Apparatus Makers Association.
Midyear Meeting of Recorder-Controller Section
Seaview Country Club, Absecon, N. J.

Oct. 27-28
First meeting Society of Exploration Geophysicists, King Edward Hotel, Toronto, Can. For information write Ralph B. Ross, chairman Eastern region program committee, Geology Div., Gulf Research & Development Co., Pittsburgh, Penna.

Nov. 5-8
Scientific Apparatus Makers Association.
Midyear Meeting of Industrial Instrument, Laboratory Apparatus, Laboratory Equipment, Optical, Aeronautical, and Military Instruments Sections. The Homestead, Hot Springs, Va.

Nov. 6-7
Tenth Annual Pittsburgh Diffraction Conference, Mellon Institute of Industrial Research, Pittsburgh, Pa. For information write E. E. Wicker, c/o U. S. Steel Co., 234 Atwood St., Pittsburgh 13, Penna.

Nov. 6-8
1952 Annual Meeting of Electron Microscope Society of America, Statler Hotel, Cleveland, Ohio. For information write Carl E. Willoughby, Program Chairman, Chemical Dep't Du Pont Experimental Sta., Wilmington 98, Del.

Nov. 17-18
AIEE Technical Conference on Electrically-operated Recording and Controlling Instruments. Benjamin Franklin Hotel, Philadelphia, Pa. For information write G. L. Broomell, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44.

Nov. 20-21
Seventh Midwest Conference, American Society for Quality Control, Claypool Hotel, Indianapolis, Ind. For information write Dale A. Cue, Vice-chairman, 7th Mid-West Conference, 5565 Brookville Road, Indianapolis, Ind.

Nov. 20-22
Instrument Maintenance Short Course sponsored by the Los Angeles Harbor Junior College and the Southern California Meter Association at Wilmington, Calif.

Dec. 3-5
Annual Meeting and Exhibits, Society for Experimental Stress Analysis, Hotel McAlpine, New York City. For information write W. M. Murray, Sec.-Treas., P.O. Box 168, Cambridge 39, Mass.

1953

Jan. 14-16
Third Conference on High-frequency Measurements. Sponsored by AIEE, IRE, and NBS. To be held in Washington, D. C.

Feb. 4-6
First meeting Western Computer Conference sponsored by joint Computer Conference Committee of Institute of Radio Engineers and the American Institute of Electrical Engineers. Hotel Statler, Los Angeles, Calif.

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On-the-Job Training In Instrumentation

On-the-job training in Instrumentation can be valuable to operating personnel as well as to instrument men and engineers. Specific suggestions are given for choice of instructor and training program.

By J. A. PARKER
Shell Chemical Corp.

JUST as Instrument Men are not provided ready-made by nature, Instrument Engineers are not turned out by colleges. Years of experience are needed to round out a man in either classification. Although there is no substitute for experience, the development of the man can be speeded by systematic training.

The Instrument Engineer in a processing plant often finds himself spending much effort in trying to get acceptance for instruments, and in defending the instruments against being blamed for every conceivable kind of process or equipment failure. He has a selling job to do. Among his antagonists are those who instrument a plant on paper with great enthusiasm but little experience. He is also well acquainted with two extreme types of operators—one who puts practically everything on manual control and the other who adjusts and repairs instruments, again with more enthusiasm than skill. For these reasons, the Instrument Engineer (and often also the foreman and the more aggressive instrument mechanic) is continually working to improve the status of instrumentation in his plant. Training is one of the tools at his disposal.

As we survey the problems of a plant from the standpoint of instrumentation, we find that there are four groups of people to be considered, each group having its own field to cover and requiring a distinctive method of approach. The groups are:

A. INSTRUMENT SPECIALISTS
   1. Instrument Engineers
   2. Instrument Men or Craftsmen
B. INSTRUMENT USERS
   1. Technical Operating Personnel
   2. Plant Operators

For each group it is necessary to consider carefully the scope of information that is to be covered, the qualifications of the instructor, the type of text and demonstrating equipment to use, and whether instruction will be given in classes, meetings, or to individuals. We are concerned here with instruction at the plant and during working hours—on company time.

Instrument Specialists

These people are generally full-time instrument personnel. Although a part-time Instrument Man or Instrument Engineer is to be found in some plants, he still requires the same field of information as the full-time specialist because he is expected to be the expert, to have all of the answers. He must know all kinds of instruments—meters, pneumatic, electronic, gadgets, etc. He must know unit processes, such as distillation, separation, and vaporization, as well as the flow plans of the plants he works in. In short, he can't know too much, and he must keep up with developments. He should be provided with text books, reference books, catalogs, and instruction books. He should be encouraged to learn on his own time by attending classes and joining appropriate organizations. It is worth-while for the employer to encourage those who are qualified to take active part in these organizations.

Presented at the Seventh Annual Symposium on Instrumentation in the Process Industries, Texas A & M College, College Station, Texas, June 2-4, 1952.

Instrument Engineers

The foregoing remarks apply more emphatically to Instrument Engineers than to the craftsmen. The engineer is usually the last resort in solving a wide range of problems. Quite often a problem comes to the engineer in the following way: An operator has a problem which appears as a process variable, such as temperature, which does not stay on the control point. Seeing no ready explanation in his operation, he calls the Instrument Man. If the Instrument Man checks the instrument and finds nothing wrong and does not see an answer in the processing equipment, he calls his foreman. If the foreman fails to see an answer, he passes the problem to the Instrument Engineer, but he, in turn, has no one to pass to. He must come up with an answer, regardless of whether the trouble is a bent flapper in the instrument or a new side reaction in the process.

It should be noted in passing that ocassionally one may find a plant with a policy which considers that instrument personnel, including engineers, need not think beyond the instrument, that, when an instrument is in good working order, it is the job of Operations to solve any further problem. This strict division of responsibilities may look good on an organization chart, but it is highly unrealistic. It leaves a gap between instrument maintenance and instrument use which can be bridged only by a knowledge of both. The Instrument Engineer fills this gap.

The raw recruit comes to us in Instrument Engineering as a college graduate who, at best, probably knows instruments only from the standpoint of the orifice run and its numerous manometers, set up in the basement of the Engineering Building, and the mathematics of a servocycle. He thinks he can calculate any orifice meter factor with only a formula which says that $Q' = CA\sqrt{2gh}$, in which C may be considered to average 0.6. He is already equipped with technical information and knows how to think objectively and how to study. He needs experience which will not only give him the "practical" view of his work but also show him that there is much useful information that was not in his school books. This deflation is necessary because he must work harmoniously with the Instrument Men and the operators. Without the cooperation of the Instrument Engineer, the shop men can handle maintenance and seem to be fulfilling their whole duty. Without the cooperation of the shop, the Instrument Engineer is reduced to a rather low level of effectiveness.

We seldom have more than one or two candidates to train as Instrument Engineers in any one plant at any one time. It is fortunate that these candidates are generally college graduates or are non-college men of unusual abilities. They have learned how to study and to rapidly increase their knowledge without the help of formal classes and assigned lessons. Almost any information placed before them will be absorbed and put to use.

It is necessary, therefore, to recognize the field of information they must cover and to make the information available to them. When technical discussions are undertaken for other personnel, such as operating and technological men, invite the Instrument Engineers to attend. In this way they can learn about proposed plants, current problems, and many subjects which will broaden their usefulness. In short,

the trainee should not have to rely upon an older Instrument Engineer for all his training because even the Chief Instrument Engineer is never through learning.

It is apparent that we are considering the Instrument Engineer as a technologist or technical service man who is specializing in instruments, regardless of whether he is in the Engineering or Technical Department or in an independent Instrument Department.

Instrument Craftsmen

Opinions differ greatly on how much an Instrument Man should know—that is, how far he should be expected to go beyond the immediate job of repairing an instrument. Ideally, the Instrument Man, in order to be of most value to his employer, should be able to shoot control and measurement troubles even though this carries him well into solving minor process problems.

Types of Craftsmen

Idealism can lead to another approach. It is fairly well conceded, especially among instrument specialists, that the Instrument Man is engaged in the most interesting craft employed by processing plants. It follows that an Instrument Man can make his vocation take on the absorbing interest that is generally thought to belong to the professions. And it becomes possible for a man whose formal education stopped at the high-school level to enter a craft which provides the means of taking pride in one's work and thus develop a large measure of self-respect.

Fortunately, some men make the most of this opportunity. They take pride in the fact that they often are trouble shooters, not only for their own craft but for operations and for other crafts as well. They discover that their role gives them a great opportunity to use their minds and that mental activity is a form of exercise that is not the least bit tiring. Some of these men even become Instrument Engineers and do justice to the title. Such men are easy to train and make use of every opportunity to learn.

Unfortunately, there are also many Instrument Men who do not discover these advantages. In those plants where the men entering the craft cannot, because of local rules and customs, be selected, some take a negative attitude toward training. It is necessary to accomplish some training even under these circumstances because it is necessary to use these men to carry some of the maintenance load.

These two groups represent the easiest and the most difficult to handle in a training program. The bulk of the average shop crew will fall in between the two extremes. It is apparent that one of the major problems is to present the training in such a way as to reach as many of the men as possible, trying to stimulate their interest and pride and to get them into a receptive attitude.

Selection of Instructor

Selection of the instructor is of prime importance. He must be acceptable to the men, all of them if possible. Preferably, he is one of them to such an extent that he is still an Instrument Man on the payroll. Furthermore, in their daily work he does the same work as the rest. He is set apart to as small an extent as possible. When the foreman or assistant foreman is the instructor, the more backward students hesitate to ask questions. They are soon lost and get little out of the training. If an Instrument Engineer with college degree, slide rule, and all the trappings is the instructor, this reticence attacks an even larger portion of the group.

Of course, the instructor must also be qualified by his knowledge and experience. He must know the subject he is teaching. To be effective, he must know more than will be covered by the course he is teaching. This broader knowledge enables him to go beyond the content of the course in answering questions. By this means he gains much in the student's respect for him and also is able to make fuller explanations to help the slower students. He gains much of his knowledge by having been an Instrument Man, learning by keeping his mind open and inquisitive. His knowledge should be extended by sending him to the schools conducted by instrument manufacturers. A good man can thus acquire enough advanced information in a few weeks to keep him busy many times as long instructing his fellow craftsmen. For the average plant, this method is far better than sending many or all of the craftsmen to such schools.

The instructor should be well qualified as an instructor. He must be able to talk fluently to a class or to an individual, having no impediments such as stage fright, inability to think before a group, a weak voice, poor vocabulary, or no sense of humor. He must be able to sense the fact when he has made an unclear explanation or moved too fast for some of the students.

Classroom Factors

Training may be administered in several ways, and all are used in a thorough program. Formal classes in the plant on company time reach the most men in a given period. They may be held for two hours each week for an extended time, or for four hours each day for five or ten consecutive working days. The latter is the more effective but may be difficult in view of the plant work load. The most effective method is to use this daily schedule with only a few, say four or six, students in the class. The lessons learned in one session are not lost before the next, and the instructor can give individual attention to each student, especially when giving actual practice on instruments.

Attendance in formal night classes in vocational schools should be encouraged. Of course, only the more interested men will attend, but since they are doing it voluntarily they will try harder to get all possible value out of the courses.

Classes should be scheduled well in advance to prevent long lapses which slow down the program. Keep complete records of what training each man has had and how well he has done. It may be well to have repeat classes at a future time for those who did poorly. Where possible, satisfactory completion of certain subjects should be a prerequisite to advancement from one classification or pay level to the next.

A ten to twenty hour course must be confined to one subject or a closely related set of subjects. A few of the subjects to be covered in such courses are (1) use and care of tools, (2) orifice meters, (3) rotameters, (4) a typical pneumatic controller, (5) a typical electronic pyrometer, and (6) control valves.

It will be found necessary to confine a course on a pneumatic controller, for instance, to one make, covering the specific components and their functions and adjustments, followed by tearing down, rebuilding and adjusting a complete instrument in the classroom. Finally, each student corrects several kinds of trouble introduced into the instrument by the instructor.

A very useful device is a classroom demonstrator, consisting of a simple controlled process and a recording controller and motor valve. The process can be a two-cubic-foot vessel being supplied with compressed air through the motor valve. The instrument is a pressure controller. The air is bled from the vessel through a hand valve, the setting of which is varied to represent changes in process load. With this arrangement all of the functions of a controller can be demonstrated with a freedom and clarity that are never permissible on an operating plant.

Individual on-the-job instruction is a very effective training method when planned properly and pursued diligently. Too often it is followed haphazardly and is ineffective.

A particular man or men should be designated as instructors and spend planned time with particular trainees on particular work. A record, such as a training time table, will insure an effective on-the-job training program.

Instrument Users

Much of the success of instrumentation in a plant depends on proper use of the instruments by the operating personnel. In the modern plant much of the actual manipulation of operating variables is accomplished by moving the indexes of the controllers. Thus instruments are much of the modern operator's contact with his plant. It follows that a proper understanding of instruments on the part of operators is all-important.

Continued on page 1282

LIQUID DISPLACEMENT METERS

By PAUL RENFREW, Ralph N. Brodie Company

Important features of positive-displacement meters include counters, measuring units, life, accuracy, and applications.

THIS discussion is limited to positive-displacement liquid meters because the problems incident to this class of meters are not necessarily applicable to a fluid meter handling a gas.

Although the positive-displacement liquid meter is about 100 years old, the performance obtained is a product of the development work of the last twenty-five years. Today the positive-displacement meter has wide acceptance. Certain classes of equipment, such as gasoline and oil delivery trucks and loading racks, are not considered complete without a meter.

Principle of Measurement

The fundamental principle of measurement of the positive-displacement meter is simple. The instrument divides the volume being measured into segments, separates each segment from the flowing stream, isolates the segment momentarily, then returns it to the stream and counts the segments.

Fundamentally the meter is a liquid motor. That is, it absorbs energy from the flowing stream. The energy absorbed manifests itself as pressure drop. Not all mechanical fluid motors make practical liquid meters. Only few of the many principles which can be employed to make efficient positive-displacement pumps are usable for making a meter because of the necessity for outside power required to produce movement of the displacement mechanism.

Characteristics

Some of the general characteristics which should be kept in mind when considering the practicability of using a mechanical principle as a meter are as follows:

1. Simplicity is the first consideration. Manufacturing and maintenance cost is always in direct proportion to mechanical complications.
2. The mechanism should be easily understood so that maintenance can be done without the necessity of special skill or training.
3. The mechanism should have sufficient strength and rigidity to withstand normal stresses as well as shock loads incident to every-day meter operation. Seldom is another instrument required to meet the high performance-standard of the positive-displacement meter.
4. It should have good mechanical efficiency so that the pressure drop is small.
5. The volumetric efficiency must produce an acceptable accuracy curve.

These characteristics must be considered collectively as well as individually; they must be in proper balance. For example, to sacrifice mechanical strength for high mechanical and volumetric efficiency might develop a structure of short life.

Specifications of "Birotor" Meter

Fig. 1 is the Brodie "Model B-72" with a maximum rating of 350 gpm. when handling light oils. This type of meter is made in a range of sizes with maximum capacity of 60, 100, 250, 350, 550, 800, and 1300 gpm. (handling light oils). This series is manufactured in four pressure ranges—150, 300, 600, and 1,000 psi. The housing is all-welded steel construction. The saddle which carries the flanges and supports the measuring unit is a steel casting. A drawn shell is welded to this saddle. The mounting pad for supporting the counter is also a steel casting.

The meter is composed of five unit assemblies—(1) housing or case, (2) counter base plate, (3) measuring unit, (4) adjustor, and (5) counter. This unitized construction is advantageous from the maintenance standpoint. For example, the measuring unit is a complete interchangeable assembly. The same unit is used in all four pressure ranges. Also, internal pressures or stresses, which might result in deformations in the external housing, are not reflected in the measuring unit. The cost of this safety feature is a slight additional pressure drop as compared to that of a single-case meter. The adjustor and counters are completely interchangeable between all sizes and pressures.

Counters

Several types of counters are available for these meters, including horizontal, vertical, "Quantrol," printing, remote counters, rate of flow indicators, and recording rate of flow indicators.

Fig. 1. (Left) Brodie "Model B-72" with "Brodimatic" counter. Maximum rated capacity is 350 gpm., measuring light oils. Working pressure is 150 psi. Fig. 2. (Right) "Model B-72" with "Series G" horizontal counter.

Presented at the Los Angeles Harbor Junior College "Instrument Maintenance Short Course," Nov. 14, 1951.

Fig. 1 shows a vertical counter. Fig. 2 shows a horizontal-type counter.

Sizes up to and including 550-gpm. units are available with the "Quantrol" counter. This feature permits the presetting of a definite quantity; when the pre-set quantity has been delivered, the flow is stopped automatically.

The adjustor used on this series of meters is a variable gear transmission. It changes the gear ration between the measuring unit and the counter in increments of 5/100 of 1 percent.

Measuring Unit

The measuring element is a liquid-sealed positive-displacement unit. Displacement is accomplished by two spiral-fluted rotors (Fig. 3). The measuring chambers are the spaces between the lobes of the rotors (Fig. 5).

The rotors are not in metal-to-metal contact with one another or with the housing in which they rotate. The clearances between them depend on the viscosity of the product being measured. They are maintained in properly timed relationship with one another by helical gears which are totally enclosed to keep thm out of the liquid stream (Fig. 4).

A practical rotary displacement mechanism which absorbs energy from a flowing stream of liquid usually is out of balance mechanically. However, the two displacement members of the "Birotor" unit are in mechanical balance, both static and dynamic. This mechanical balancing produces some novel characteristics. There are no shock loads on the bearings or the mechanism because of the shifting of off-balance masses. Also, a measuring unit which is in mechanical balance is far less susceptible to damage during the period of filling the empty meter with liquid. The shock resulting from the sudden entrance of noncompressible liquid into a measuring mechanism which is operating at or near its maximum rpm. on air or vapor is frequently damaging to most meters.

The performance of the "Birotor" meter thus far has exceeded the expectations of its designers. Although we are unable to predict just what its life expectancy will be, we believe it will be much longer than the time estimated for amortization of capital equipment of this class by most companies.

Factors Controlling Meter Life

The life expectancy of any positive-displacement pump or meter depends on many factors, including (1) the lubricating qualities of the liquid handled and (2) the amount and particle size of abrasive matter in relation to the viscosity of the liquid handled.

Positive-displacement meters for measuring nonviscous liquids, such as aviation motor fuel, are necessarily closely fitted mechanisms. On the other hand, a meter fitted to handle lube oil, or a heavy fuel oil of 1500 or 2000 Seconds Saybolt, could have considerably more clearance. Thus the latter unit would pass abrasive matter that might be disastrous to the more closely fitted unit.

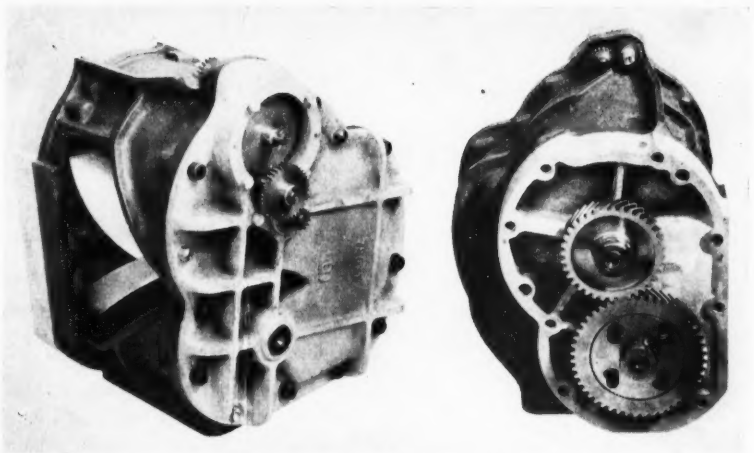


Fig. 3. (Left) Measuring element showing inlet port and spiral-fluted rotors. Fig. 4. (Right) "Model B-72" measuring element with gear cover removed to show the rotor timing gears.

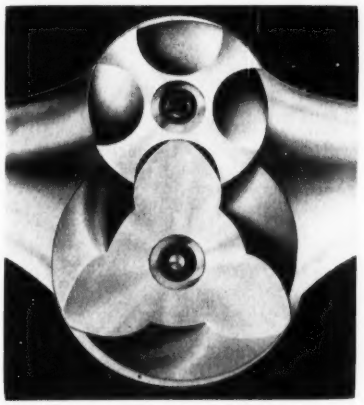


Fig. 5. Section through rotors to show measuring chambers.

Meter life is influenced further by the rate of flow and the continuity of operation. A meter operating continuously at its maximum recommended rate has a shorter life than one running intermittently at half speed.

The maximum and minimum capacity ratings of a positive-displacement meter represent the range of flows over which the meter shows acceptable performance characteristics—that is, acceptable mechanical and volumetric efficiency. The maximum capacity usually is established on the basis of intermittent operation, and is reduced somewhat as operation becomes more or less continuous.

Furthermore, the ratings usually are established for liquids in the viscosity range of gasoline through kerosene, automotive diesel fuel, etc. As viscosity decreases from kerosene down through hi-octane gasoline, butane, propane, and so forth, we recommend reduction in maximum rate at which the meter is run. This reduction is made because of lack of lubrication with these products. The maximum rating is reduced as the viscosity increases for the same reasons that rate is reduced in a pipe line.

Factors Controlling Accuracy

The accuracy curve of a meter, which is a reflection of its volumetric efficiency, is influenced by the physical characteristics of the liquid being measured, principally viscosity. Most positive-displacement meters are of the liquid-sealed class. In any liquid-sealed meter there is some slippage or flow of liquid through the sealing clearances. For any given set of conditions, the slippage increases as the viscosity decreases and, conversely, decreases as the viscosity increases. When viscosity increases to a point where the liquid film supports the differential pressure, slippage ceases. The greatest change in this slippage factor occurs at viscosities below 1½ or 2 centipoises.

Radical changes in differential pressure also affect the slippage factor, especially when measuring a nonviscous liquid such as high-octane aviation gasoline. Such changes in pressure differential result from a change in either mechanical friction within the measuring mechanism, or a change in work done—that is, counter load, packing-box friction, etc.

There is no contact between the rotors or between the rotors and the body in which they rotate. Furthermore, there will be no contact and therefore no change in mechanical friction as long as the bearings and gears maintain the rotors and body in proper relationship. If there is no change in the outside load (driving of counter, packing-box friction, etc.), there should be no change in accuracy.

Application

There are certain jobs that only a positive-displacement meter will do properly. However, like other mechanical mechanisms it has its limitations.

This type of instruments has made a real place for itself in the operation of a refinery or pipe-line terminal loading racks. It provides means for operational and accounting procedures which enable plant management to control truck and transport loading. The difficulty of

Continued on page 1299

The Art and Science of

INDUSTRIAL INSTRUMENTATION

By ROBERT TOBI, Los Angeles Harbor Junior College

Instrumentation has two facets—measurement and control. Each is still both an art and a science.

INDUSTRIAL instrumentation may be defined as the art and science of measurement and control for the process industries. This definition allows the discussion to be broken into four parts—(1) the science of measurement, (2) the art of measurement, (3) the science of control, and (4) the art of control.

Science of Measurement

To measure is to determine the size or extent of a quantity or condition by comparison with a standard. Standards are the result of systematized studies. For example, the unit of length is the distance between two lines on a bar which is kept at the International Bureau of Weights and Measures at Sevres, France. All measurements of length are referred to that standard. The name given to the unit of length adopted as a standard in this country is the yard. A smaller unit is the foot. We compare all distances or length measurements to these standards.

In the case of temperature measurements the melting points and boiling points of various pure substances are used as standards. Melting points and boiling points are fixed temperature points.

Measuring instruments are devices that are used to compare quantities or conditions to the established standards. These instruments operate on physical and chemical principles. For example, temperature-measuring instruments are based on principles such as the gas laws, laws of vapor pressure, linear and cubical expansion, thermoelectric effect, etc. The same principles are utilized in the measurement of pressure, liquid level, and flow rates as are Archimedes' principle, Pascal's law, and Bernoulli's equation. It is the application of these principles that makes possible indirect measurement. Flow rates are determined from the measurement of a pressure drop, and the pressure drop is determined from the distance a pointer moves on a dial. The conversion from the pointer position to a flow rate is possible only with a complete knowledge of the principles involved. It should be noted that there are very few direct measurements.

The design of a thermal system is based on gas laws, laws of vapor pressure, or the expansion of liquids with temperature—depending on the filling medium used. Fig. 1 shows a typical temperature-measuring system. Calibration is possible because of the elastic properties of the Bourdon tube.

The science of measurement is truly systematic whether measurements are direct or indirect. Using the scientific method makes reproducible measurements possible and results in a high degree of accuracy. Instrument calibration, which is the act of checking the accuracy of the graduations of a measuring device, belongs in the science of measurement.

Art of Measurement

The art of measurement depends on skills acquired by experience and observation. Although science allows us to construct measuring devices, there are no general laws specifying when or where to use instruments or what types of instruments should be used. No laws specify whether to use a diaphragm-type, bellows-type, or mercury-type differential-pressure instrument (Fig. 2). Selection of equipment may

Continued on page 1298

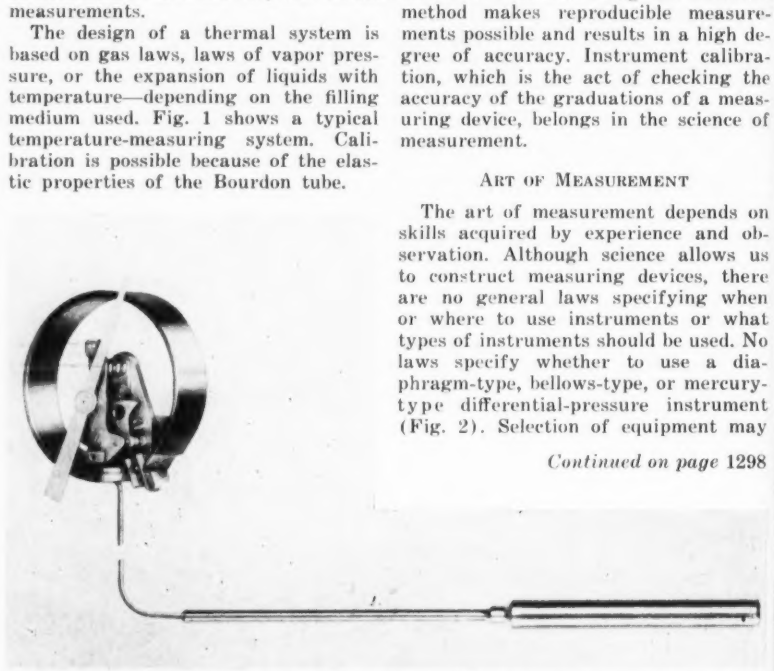


Fig. 1. The science of measurement. Scientific principles determine the construction of this typical temperature-measuring system.

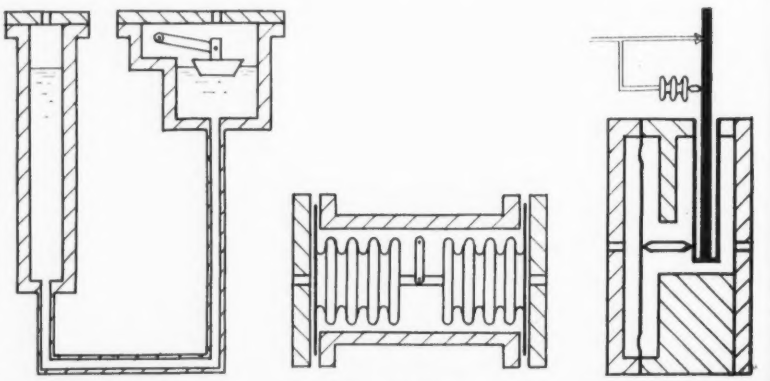


Fig. 2. The art of measurement enters into the choice of these typical differential-pressure instruments for a particular application.

Presented at the Los Angeles Harbor Junior College "Instrument Maintenance Short Course," Nov. 14, 1961.

INSTRUMENT ELECTRONICS

Basic test equipments include the (1) permanent-magnet moving-coil, moving-iron, and electrodynamic movements, (2) volt-ohm-milliammeters, (3) vacuum-tube voltmeters, (4) tube testers, (5) signal generators, (6) oscilloscopes, (7) instrument transformers, (8) frequency meters, and (9) field-intensity meters. Principles and features of each type are discussed.

By MILTON H. ARONSON
Technical Editor, *Instruments*

XII. ELECTRICAL AND ELECTRONIC TEST EQUIPMENT

MOST electronic equipment can be classified as either (1) test equipment, (2) communication and telemetering equipment, (3) military and navigation equipment, or (4) industrial and research equipment. Basic types of test equipments are discussed in this chapter.

Electrical Indicating Movements

There are three basic types of instrument movements for indicating current or voltage—the permanent-magnet moving-coil (p.m. m-c.), the movable-iron, and the electrodynamic. Although the p-m. m-c. is used in most portable field equipment, the others have use at power frequencies and as laboratory indicators. The characteristics of the basic movements are listed in Table VII. The accuracy of panel-type instruments is usually less than laboratory types by a factor of 2 or 3.

Permanent-magnet Moving-coil Movement

The heart of most electrical indicating instruments is the permanent-magnet moving-coil movement (Fig. 12-1), which is simply a moveable coil located in the field of a permanent magnet. *Direct current* in the coil produces a magnetic field that reacts with the fixed magnetic field, producing a torque that rotates the coil. When the field is uniform, and when the rotation of the coil is opposed by springs, the coil motion is linear with current. The pointer indicates the current in the coil. Note that the path of current is through the springs and the coil. The p-m. m-c. movement sometimes is called a D'Arsonval movement.

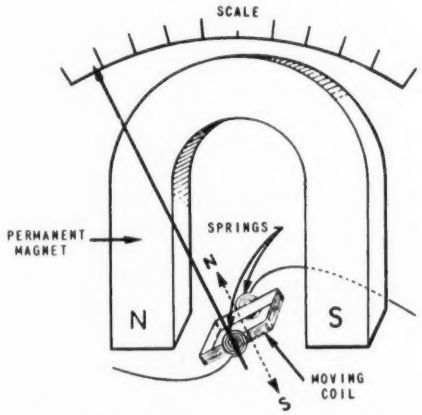


Fig. 12-1. Elements of a permanent-magnet moving-coil (p-m. m-c.) movement.

ANSWERS TO QUIZ XI (Part 2)—SIGNAL-SHAPING CIRCUITS

11-13.	(b)	11-16.	(a)	11-19.	(b)	11-22.	(a)
11-14.	(d)	11-17.	(c)	11-20.	(a)	11-23.	(c)
11-15.	(a)	11-18.	(c)	11-21.	(b)	11-24.	(c)

Test items for XII—Page 1296

A common production model is the 1-milliampere movement—that is, 1 milliampere causes full-scale deflection. Although higher currents can be read by shunting the meter with resistors, more-rugged 25- and 50-milliampere movements usually are used with shunts for measuring direct currents of amperes.

A variation of the permanent-magnet moving-coil movement is the fixed-coil moving-magnet movement. It operates on the same principle, has lower sensitivity, but is a sturdy low-cost device.

A-c. measurement. The permanent-magnet moving-coil movement is a d-c. movement. For a-c. measurements, movements with built-in full-wave rectifier elements in a bridge circuit are available. They are useful for frequencies up to about 10 kc. The rectifier bridge circuit measures average, not rms., values. Therefore, when scale is marked in rms. units, the instrument should be used on sine waves only.

For radio-frequency measurements (usually of current), a resistance heater and a thermocouple junction are used with the p-m. m-c. movement. The heat developed by the current develops a proportional thermoelectric emf., which deflects the movement. The thermocouple instrument is usable to several Mc., and indicates rms. valves of any waveform. As it responds with equal accuracy to d.c., it can be calibrated with d.c.

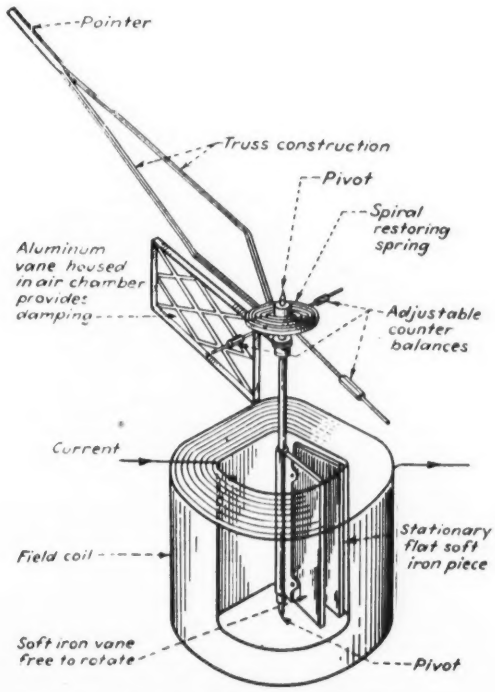


Fig. 12-2. Moving-iron movement.

Table VII—CHARACTERISTICS OF PORTABLE AND PANEL-TYPE ELECTRICAL INDICATING MOVEMENTS

	Permanent-magnet Moving-coil	*P-m. m-c. plus rectifier*	*P-m. m-c. plus thermocouple*	*Moving Iron*	*Electrodynamometer*
Use	D.c	A.c. to 10 kc. (average, not rms.)	A.c. to several Mc. (rms.)	A.c. from 25 to 125 cps. (rms.) Can be used for d.c.	D.c. or A.c. to 200 cps. (rms.)
Principle	Permanent magnet, moving coil.	Bridge rectifier plus p-m. m-c.	Thermocouple and resistance element plus p-m. m-c.	Iron vanes in field of one coil.	Current flows through two coils, one fixed, one moveable
Voltage	Internal series resistor plus external multiplier for high voltages	Series resistor in a-c. input	Series resistor (not usually used for voltage)	With series resistor, up to several hundred volts	Coils in series, series resistor
Current	With shunts (internal or external) to several hundred amperes. Coils available to carry from 20 ua. to 25 ma.	Usually used only for ma. or ua. because rectifier is limited to about 10 or 20 ma.	Limited only by resistance element, several ma. to several hundred amperes.	Several hundred amperes	Coils in series, shunt across moving coil only
Scale	Linear	Linear	Usually compressed at low end; may be expanded by magnetic field distribution	Either compressed at low end or linear. Depends on construction	Compressed at low end
Accuracy of Portable Laboratory Types	0.5%	5% because of rectifier aging	over 5% for d.c. or low frequency. Ambient temp. error.	1%	0.1% in lab. standards
Features	Economy, good accuracy. Higher sensitivity than other movements	Economy. Sensitivity of 1000 ohms per volt	R-f. measurement. Full-scale response about 15 mv. Current overload dangerous.	Ruggedness, economy, needs supplementary damping. Many variants.	Excellent accuracy. Wattmeter use. Less subject to waveform and frequency error.

Moving-iron Movement

Although the p-m. m-c. movement is the most common indicator in electronic test equipment, moving-iron and dynamometer movements are used commonly for particular applications. The *moving-iron movement* (Fig. 12-2) consists of one fixed iron vane and one movable iron vane, both in the field of a winding. The vanes repel each other when the current to be measured flows through the field winding. The meter is produced as a voltmeter or ammeter, a.c. or d.c. For voltage measurement the field coil consists of many turns of fine wire so that the field is proportional to the voltage to be measured; for current measurement the field winding consists of a few turns of heavy wire. The instrument is inexpensive, is usually used for measuring a.c., and can be made very rugged. The scales are not exactly the same for d-c. and a-c. measurements. Thus forward and reverse readings should be made with d.c. It is a common type of power-frequency voltmeter or ammeter, and several variants are available with long uniform scales.

Electrodynamic Movement

The electrodynamic movement (Fig. 12-3), or electrodynamometer, consists of two windings, one fixed and one movable. The current to be measured flows through both windings. The fixed, or field, winding produces a field that interacts with the field produced by the movable winding. Note that the electrodynamic movement is similar to the p-m. m-c. movement except that the fixed field winding replaces the permanent magnet. It is used commonly as a wattmeter, with the field coil used as the "current coil" and the moving armature coil used as the "potential coil." As the calibration is the same on d.c. as on a.c., it is used in the laboratory as a "transfer standard" for transferring from d-c. to a-c. or a-c. to d-c. measurements. High accuracies (to 0.1 percent) are available in electrodynamic laboratory standards.

Voltage Measurement with P-m. M-c. Movement

For measuring voltage, appropriate resistors are placed in series with the p-m. m-c. movement. For example, to make a 1-ma. movement have 1-volt full-scale deflection, a resistor is placed in series with the movement so that the total resistance of resistor and meter movement is 1000 ohms (1 volt applied across 1000 ohms produces 1-milliampere current). For 10-volt full-scale indication, a total resistance of 10,000 ohms is required. Note that the resistance of this simple voltmeter is a fixed 1000 *ohms per volt*. Thus the 1-ma. movement often is called a 1000-ohms-per-volt movement, referring to its resistance when used as a voltmeter.

A 50-microampere movement has 20 times the sensitivity of the 1-ma. movement and often is called a 20,000-ohms-per-volt movement. Similarly, a 20-microampere movement is a 50,000-ohms-per-volt movement. These movements, used for measurement of microamperes and for voltage measurements of high-impedance sources, are more expensive than the 1-ma. movement.

Resistance Measurement with P-m. M-c. Movement

Resistance measurement can be made with a p-m. m-c. movement and a fixed, known voltage. When the movement and the fixed voltage are put in series with the unknown

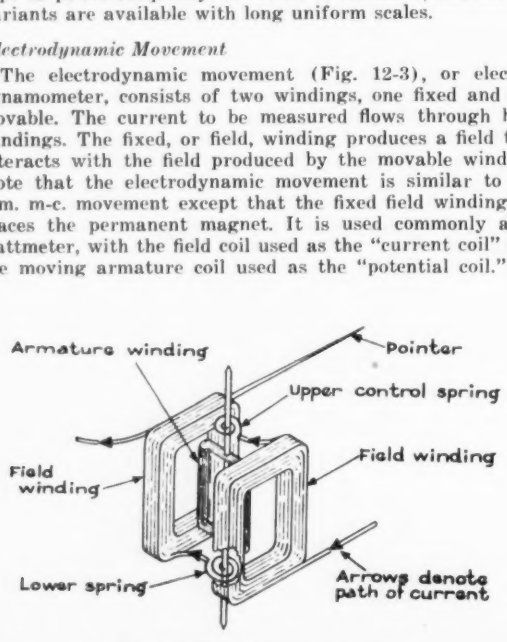


Fig. 12-3. Electrodynamic movement.

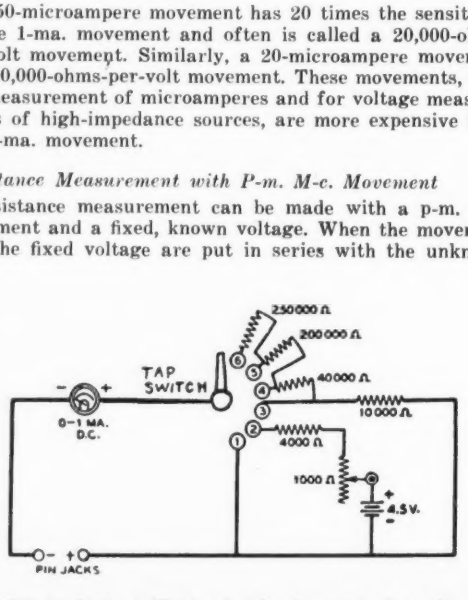


Fig. 12-4. A simple multimeter for direct current, d-c. voltage, or resistance. Switch positions are (1) 0-1 milliampere, (2) 0-100,000 ohms, (3) 0-10 volts, (4) 0-50 volts, (5) 0-250 volts, (6) 0-500 volts.

resistance, the current through the meter depends on the value of the unknown resistance; the scale can be calibrated directly in ohms. Ohmmeters have built-in batteries or low-voltage power supplies for supplying the fixed voltage.

Volt-ohm-milliammeter

A common test instrument is the portable volt-ohm-milliammeter. It usually is a p-m. m-c. milliammeter or microammeter (20 or 50 microamperes full-scale) with a switch for selecting either (1) appropriate shunt resistors—for measuring various currents, (2) series resistors—for measuring various voltages, and (3) series resistors and internal voltages—for measuring various resistances. Different scales are selected as shown in Fig. 12-4. Measurement of a-c. voltage and current is made by using a germanium crystal, a copper-oxide rectifier, or a selenium-oxide rectifier to rectify the a-c. voltage or current into a d-c. signal. Rectifier-type multimeters usually are designed for power or audio frequencies and have considerable error at radio frequencies.

Vacuum-tube Voltmeters

The vacuum-tube voltmeter (VTVM) is one of the most basic and useful test instruments. It is simply a vacuum tube in which plate current (or plate voltage) is calibrated in terms of the voltage applied to the grid. The plate current usually is measured by a permanent-magnet moving-coil meter in the plate circuit.

Fig. 12-5 shows a conventional VTVM. The input voltage to be measured is applied to the grid of one vacuum tube. The second vacuum tube has its grid at a fixed potential. A D'Arsonval-type milliammeter or microammeter indicates the difference in cathode potentials of the two tubes. The second tube is used to balance out tube and supply variations so that the zero setting does not drift.

D-c. Measurement

For d-c. measurements the input signal can be applied to the grid of the calibrated tube, either directly or through a high-resistance voltage-divider that functions as a range switch.

A-c. Measurement

For a-c. measurements the d-c. input signal must be rectified into a d-c. signal. When the VTVM has a diode inside the meter case, it usually is intended for power- or audio-frequency measurements because the capacitance of the lead wires bypasses r-f. voltages to ground, thereby destroying them. For r-f. a-c. measurements to several hundred Mc., a special low-capacitance *probe* (Fig. 12-6) is used with the VTVM. The probe contains a diode or crystal rectifier that rectifies the signal and charges a capacitor in the probe. The circuit is put in the tip of the probe so that lead-wire capacitance can not affect the signal.

For a-c. measurements a VTVM can be responsive to peak, average, or rms. value of the signal, depending on the type of circuit. Of course the calibrated dial can be marked in terms of any value (usually rms.). The probe in Fig. 12-6 charges the capacitor to the peak value of the input signal. (The second section of the diode is used to cancel the "contact" potential that a diode develops when it has no signal.) Hence the circuit in Fig. 12-6 is responsive to peak value of applied signal. Some VTVM's use a biased triode as an a-c. indicator; this type indicates the *average* value of plate current and hence responds to the *average* value of a-c. signal. Thermal-type detectors respond to rms. values. The type of response becomes important when measuring nonsinoidal waveforms because the conversion from peak or average to rms. value will be in error when nonsinoidal waveforms are measured. Unless otherwise specified, a VTVM should be used for measurement of sine waves only; special VTVM's are available for pulse measurements and for measurement of millivoltages.

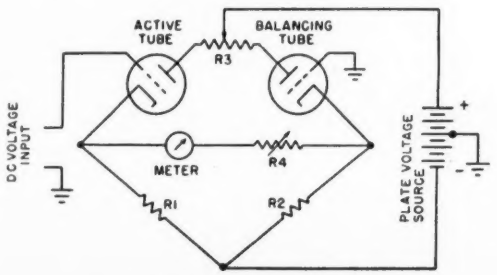


Fig. 12-5. Vacuum-tube voltmeter circuit.

Features and Advantages

The important characteristics of a VTVM are (1) high input resistance for d-c. measurements, (2) high input impedance for a-c. measurements, (3) several voltage ranges, (4) wide frequency range for a-c. measurements, (5) high sensitivity, (6) protection against overloads, and (7) other scales for current or resistance measurement.

Input resistance. The outstanding advantage of the VTVM is the high input resistance resulting from the fact that the signal is applied to the grid of a vacuum tube, which draws little current. The input resistance of any test instrument determines its effect on the circuit being measured. In the instrument shown in Fig. 12-4, the circuit being measured must supply at least 1 milliampere—that is, the input resistance of the instrument is 1000 ohms per volt. In contrast, the input resistance of a VTVM is determined by the grid current of the input (Fig. 12-6) or by the input voltage divider, if one is used. In most VTVM's, a 1- or 10-megohm resistor is placed in series with the input so that the input resistance always is high (more than 10 megohms). Owing to the high input-impedance of a VTVM, high-impedance points (such as plate and grid voltages in electronic circuits) can be measured without drawing much current from the point being measured.

Input impedance. The input impedance for a-c. measurements depends on the probe circuit. Most VTVM probes are useful from 30 or 60 cps. to several hundred Mc. The input impedance is specified as a resistance in series with a shunt capacitance.

Voltage ranges. Conventional VTVM's have several voltage ranges from 0-1 to 0-1000 volts. Special VTVM's have even wider voltage ranges. Owing to the fact that the vacuum tube is a power amplifier, the VTVM is more sensitive than a p-m. m-c. multimeter for voltage measurements. For extending the voltage range above 1000 volts, a special resistance voltage-divider in the tip of a well-insulated probe is available. Special VTVM's are available with extended sales—that is, a small portion of the scale can be extended over the full scale so that highly accurate readings (within a few millivolts)can be made at any voltage.

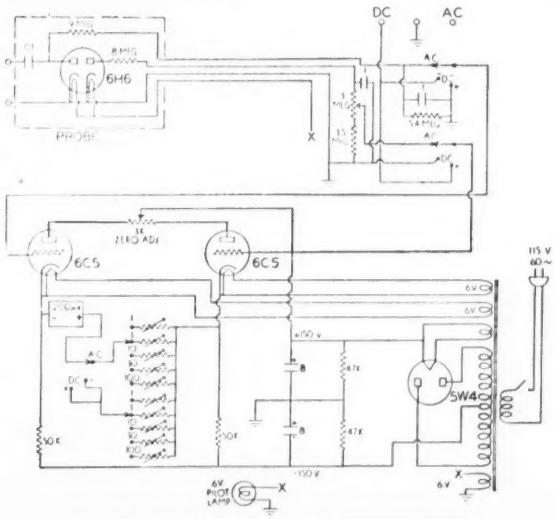
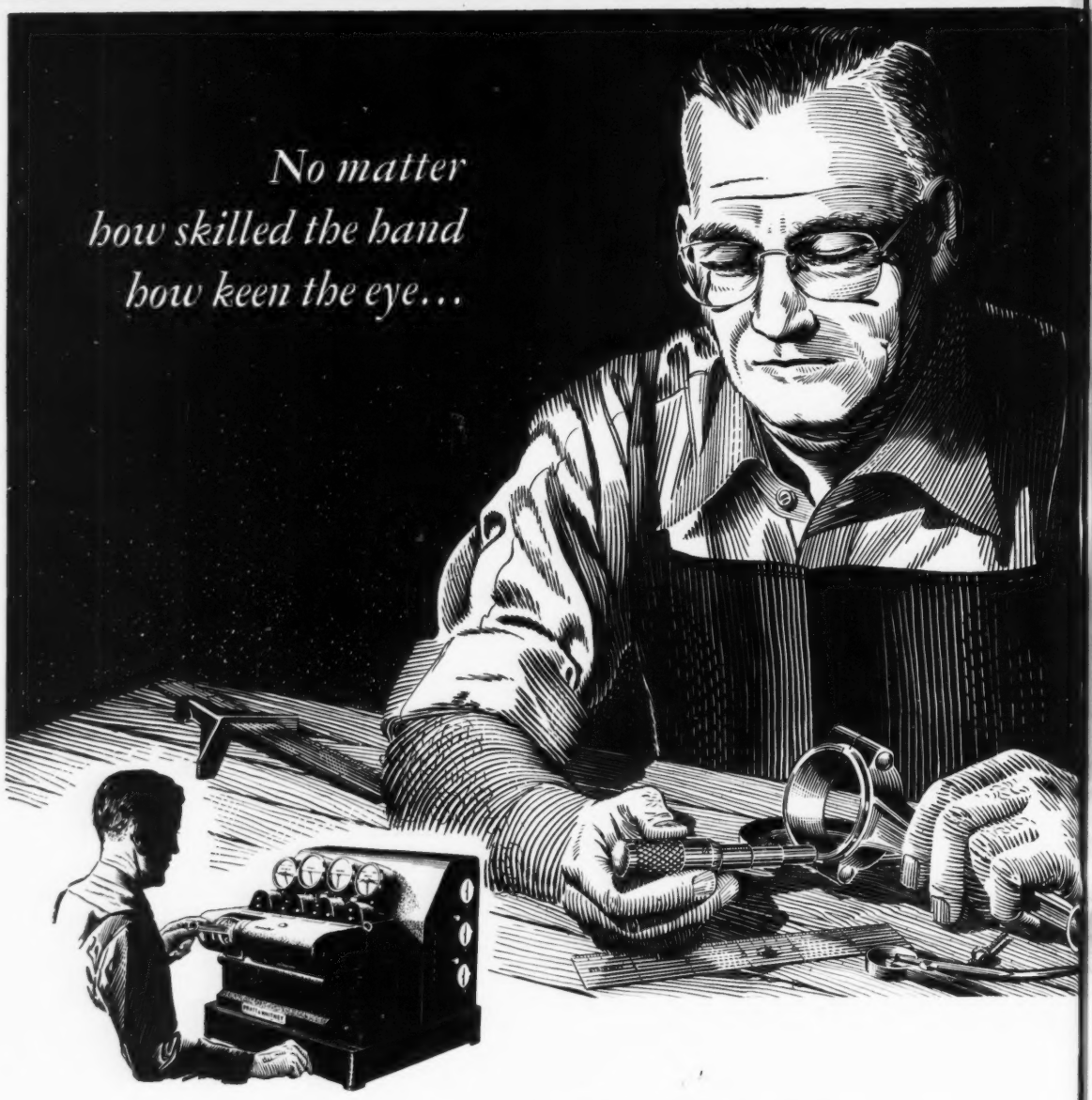


Fig. 12-6. "Model 62" VTVM of Measurements Corp.

Continued on page 1286



No human sense can approach the accuracy of scientific measurement.

Progress and profits in manufacturing are profoundly dependent upon instruments . . . those myriad devices that constantly work to reduce waste, to insure purity and quality and as near perfect mechanical performance as it has been given mankind to achieve.

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Journal

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THE MANAGER'S PAGE

Percy V. Jones, Jr.

BY the time this issue of the Journal is in your hands, the excitement will have died and the Seventh National Instrument Conference and Exhibit, about which you have been hearing so much during the past months, will be another chapter in the history of ISA.

It was intended to include in this column a brief record of what has been accomplished by the Instrument Society of America during the past twelve months. That record is so thoroughly and capably covered in the reports of President Beckman, Secretary Hart, and Vice-President Sheen, that there is little left to say.

The report by Treasurer Feeley which appeared in the April issue of the *Journal* gave a clear exposition of the financial status of the Society.

The growth of ISA during the past year has been a source of continuing satisfaction to your Manager, who wishes to express his appreciation for the complete cooperation he has received from the Executive Board, National Committees, local Sections, and the many individual members of the Society with whom he has worked. Especial thanks are due to Dick Rimbach for the helpful cooperation and advice he has so unstintingly given during the past year.

ISA MEMBERSHIP REPORT 4/1/47—9/1/52

Section	*Charter Date*	4/1/47	8/1/47	8/1/48	9/1/49	9/1/50	9/1/51	9/1/52	*Percent Change (9/1/51-9/1/52)*
Akron	7/19/48			14	43	36	30	43	43
Albuquerque	7/16/49					59	46	46	
Aruba	1/24/47	26	28	64	59	39	41	35	-15
Atlanta	8/23/48			16	20	17	24	41	71
Baltimore	1/10/46	60	60	63	69	76	81	99	22
Baton Rouge	5/10/49					47	23	12	-48
Boston	7/28/48				86	105	121	150	24
California	1/10/46	31	47	103	164	167	174	250	44
Carolina Piedmont	1/18/52							51	
Central Illinois	3/ 8/48			26	30	36	33	31	6
Central Indiana	1/30/47	65	81	82	78	80	77	79	3
Central New York	5/15/50					18	31	29	-6
Central Ohio Valley	3/27/52							42	
Charleston	1/10/46	112	91	80	81	68	65	83	13
Chicago	1/10/46	232	245	270	299	342	321	347	8
China Lake	1/17/49				86	41	24	17	-29
Cincinnati	3/ 7/47	39	43	58	65	62	66	80	21
Cleveland	1/10/46	110	119	127	122	129	122	148	21
Columbus	7/16/49					26	22	24	9
Cumberland	4/24/46	27	31	19	15	14	20	27	35
Denver	7/26/51						51	79	55
Detroit	1/10/46	82	83	79	75	65	59	57	-3
Eastern New York	1/20/47			58	90	98	87	94	8
Gulf Coast	1/10/46	26	28	46	42	41	34	49	44
Houston	3/16/48			82	113	134	147	196	33
Kansas City	1/10/46	36	38	49	53	57	74	70	-5
Lake Charles	7/18/52							19	
Louisville	3/ 7/47	41	53	38	39	37	45	51	13
Montreal	6/16/48			38	72	82	77	94	22
Muscle Shoals	6/17/52							35	
New Jersey	1/10/46	133	146	189	227	232	280	355	27
New Orleans	4/11/46	5	9	9	4	10	9	7	-12
New York	1/10/46	122	132	150	214	250	261	274	5
Niagara Frontier	7/31/47		48	120	90	91	99	146	45
North Texas	2/16/49				40	24	13	14	8
Northern California	9/10/49					102	94	111	18
Northern Indiana	1/10/46		21	28	23	26	45	47	4
Oak Ridge	8/27/46	67	69	55	67	66	76	78	3
Ontario	1/10/46	65	61	39	43	41	44	36	-18
Panhandle	2/10/50					45	39	34	-12
Permian Basin	12/ 2/51							59	
Philadelphia	1/10/46	242	263	328	381	330	339	361	6
Pittsburgh	1/10/46	152	157	185	219	241	238	271	14
Presque Isle	7/31/47		2	24	22	18	20	27	35
Richland	1/ 1/48			124	99	72	107	167	56
Rochester	2/16/48			60	67	77	88	92	5
Sarnia	9/ 1/47			99	77	77	85	104	22
Savannah River	3/27/52							45	
South Bend	3/ 7/47	21	27	23	10				
South Michigan	11/11/46	42	51	45	34	26	27	29	7
South Texas	11/11/46	86	50	42	46	61	69	67	-3
St. Louis	1/10/46	68	79	82	112	132	114	128	12
Tennessee	1/10/46	36	23	40	41	46	50	53	6
Toledo	4/15/50					27	42	51	12
Tulsa	9/ 6/47			75	82	96	107	131	22
Twin Cities	3/10/47		11	46	44	36	43	46	7
Washington	1/10/46	121	141	134	143	116	134	156	16
Wayne County	1/10/46	40	41	42	45	73	89	168	89
Wilmington	12/ 2/49					77	90	101	12
At Large					27	28	52	42	-19
Foreign						..		18	
Corporate								1	
TOTAL MEMBERS		2121	2296	3280	3880	4298	4549	5597	23

SECTIONS AND MEMBERSHIP REPORT

8/1/46—9/1/52

Date	*Number of Members*	*Number of Sections*
8/46	1075	21
12/46	1650	23
4/47	2121	27
8/47	2296	32
3/48	2966	38
8/48	3280	41
3/49	3762	44
5/49	3908	44
9/49	3880	47
1/50	4224	49
6/50	4300	52
9/50	4298	52
3/51	4557	52
9/51	4549	52
3/52	5414	55
9/52	5597	58

MEMBERSHIP RECORD BY SECTIONS, BY GRADE

Sections	*FM**	*AM*	*SM*	*Total*
Akron	42		1	43
Albuquerque	30	16		46
Aruba	35			35
Atlanta	40	1		41
Baltimore	95	4		99
Baton Rouge	12			12
Boston	149	1		150
California	250			250
Carolina Piedmont	50		1	51
Central Illinois	30	1		31
Central Indiana	33	45	1	79
Central New York	29			29
Central Ohio Valley	42			42
Charleston	80	3		83
Chicago	253	19	75	347
China Lake	16	1		17
Cincinnati	79	1		80
Cleveland	146	2		148
Columbus	19	4	1	24
Cumberland	25	2		27
Denver	77	2		79
Detroit	55	2		57
Eastern New York	61	8	25	94
Gulf Coast	41	7	1	49
Houston	187	6	3	196
Kansas City	61	9		70
Lake Charles	19			19
Louisville	47	4		51
Montreal	91		3	94
Muscle Shoals	29	1	5	35
New Jersey	354	1		355
New Orleans	7			7
New York	221	10	43	274
Niagara Frontier	119	21	6	146
North Texas	14			14
Northern California	111			111
Northern Indiana	44	2	1	47
Oak Ridge	78			78
Ontario	35	1		36
Panhandle	34			34
Permian Basin	57	2		59
Philadelphia	347	11	3	361
Pittsburgh	268		3	271
Presque Isle	24	3		27
Richland	115	7	45	167
Rochester	91		1	92
Sarnia	95	9		104
Savannah River	45			45
Southern Michigan	19	9	1	29
South Texas	61	6		67
St. Louis	126	2		128
Tennessee	33	17	3	53
Toledo	51			51
Tulsa	128	3		131
Twin Cities	34	11	1	46
Washington	90	66		156
Wayne County	122	43	3	168
Wilmington	99	2		101
Total Members of Sections	4945	365	226	5536
Per Cent of Total	90%	6%	4%	100%
At Large				42
Foreign				18
Corporate				1
Total Membership				5597

*FM—Full Member AM—Associate Member
SM—Student Member

President's Report

It is a pleasant duty to review the operations of the Society for the past year because substantial progress has been made in a number of ways.

Since the last Annual Meeting, which was held in Houston September 10, 1951, the number of sections has increased from 52 to 58. The 6 new sections are Permian Basin, Carolina Piedmont, Central Ohio Valley, Savannah River, Muscle Shoals and Lake Charles. To these new sections, I extend an official welcome on behalf of the Society.

The number of Members has increased from 4549 on September 1, 1951 to 5597 as of September 1, 1952. There are now 4945 Full Members, 365 Associate Members, 226 Student Members, 42 Members-at-Large, 18 Foreign Members, and 1 Corporate Member.

The Society is in sound financial condition, as is shown by the Treasurer's detailed report. For the calendar year 1951, Income exceeded Expenses by $14,457.62 and on December 31, 1951, the Cumulative Surplus was $67,206.19. It is anticipated that the Cleveland Exhibit will be the most profitable exhibit thus far held by the Society and that there will be a substantial contribution to Surplus as the result of operations for 1952.

These statistics clearly show the growth of the Society and they are indeed gratifying. The growth of the Society is shown also in less specific ways which are equally gratifying to those of us who have been closely associated with the Society's activities. There is an increasing awareness by members and by industry of the important role which the Society can and shoud play in the fields of Instruments and Instrumentation. There is increasing recognition by professional, scientific and engineering organizations of the fact that our Society is rapidly gaining stature and prestige. The Society is expanding into new fields of instrumentation and, in general, there has been a marked improvement in its procedures and in its business administration. The Society is gaining broader vision, increased vigor and a more mature viewpoint, as well as more members.

The adoption of the new Constitution and By-Laws was a constructive forward step. In accordance with the resolution passed at the Houston meeting, the revised Constitution and By-Laws were submitted to the members for a mail ballot. The vote was 1228 to 162 in favor of adoption, and the new Constitution and By-Laws became effective on December 8, 1951. The new Constitution and By-Laws corrected inadequacies of their predecessors and incorporated new Articles made necessary by the growth of the Society, such as a Committee on Public Relations and additional technical committees in medicine, meteorology, radiation, geophysics and physical measurements.

An important change in the By-Laws is the provision for a Society Manager. Prior to adoption of the new By-Laws, Mr. Richard Rimbach, Executive Secretary of the Society since its founding, managed the Society's affairs. The growth of the Society made the task increasingly burdensome and full-time services of a paid manager became imperative. Mr. Percy V. Jones, Jr. has served capably as Society Manager during the past year. The National Office of the Society was established at 1319 Allegheny Avenue, Pittsburgh 33, Pennsylvania. I am happy to report that when the operations of the National Office were reviewed at the July meeting of the Executive Board, Mr. Jones was commended for the excellent manner in which he has performed his duties.

It is appropriate here to say a few words of appreciation to Dick Rimbach. He, more than any other indi-

Continued on page 1270

National Committees and Chairmen

Society Structure & Planning—Nelson Gildersleeve.
Nominating—G. F. Akins
Constitution, Rules & Procedures—R. L. Galley
Instrument Industry—Charles L. Saunders
Finance—J. T. Vollbrecht
Meetings and Exhibits—E. J. Grace, Jr.
Publications—C. W. Covey
Sections and Membership—M. D. Shriver
Employment—P. V. Jones
Intersociety Relations—Everett S. Lee
Public Relations—Douglas M. Considine
Government Relations—Ralph L. Goetzenberger
Educational Committee—Prof. Robert J. Jeffries
Historical—L. M. Susany
***Technical Program**
Research and Development
Instrument Operation & Maintenance
J. Johnston, Jr.
Testing Instrumentation—D. C. Little
Analysis Instrumentation—Axel H. Peterson
Instrumentation for Inspection & Gaging
W. A. MacCreahan
Instrumentation for Production Processes
W. H. Brand
Instrumentation for Transportation
F. H. Catlin
Medical Instrumentation—Dr. H. J. Morowitz
Meteorological Instrumentation
Christos Harmantas
Radiation Instrumentation—Richard W. Johnston
Geophysical Instrumentation—Dr. David Muzzey
***Physical Properties Measurement**
Aeronautic Instrumentation—Robert Tozier
Recommended Practices—A. V. Novak

**Chairman not assigned*

Report of Robert T. Sheen, Vice President General Relations Division

Committee C-1 Sections & Memberships

This committee has been most active during the year and what is more important has been quite successful in its efforts to assist in the building of ISA. The following Sections have been added:

Permian Basin
Carolina Piedmont
Central Ohio Valley
Savannah River
Muscle Shoals
Lake Charles

At the moment it appears that we may have still another Section for this annual meeting, the Fox River Valley Section at Neenah, Wisconsin. In addition to the Sections already added, there is active correspondence with twelve additional prospective Sections at the present time.

Numerically, our membership shows an increased membership of 1048 as of the present time. Millard Shriver, the Chairman of this committee, was unfortunately taken ill early in the year, therefore, Mifflin Jacobs, Past Chairman, agreed to step back in the saddle and pitch during Millard's absence. Between these two men this year, the above noted progress has been made.

Committee C-2 Employment Committee

Mr. Percy V. Jones, our Society Manager, is Chairman of this committee. Positions listed in the Journal are running at the rate of 200 to 250 per year. Between 500 and 600 applications are being received per year including applications at the Annual Show. Routine acknowledgements, filing, maintaining records, mailing of applications, issuing letters of instructions, correspondence and personal interviews of prospective employers and employees consume an estimated 25 hours monthly, about 20 hours of which are clerical time. This being time of the headquarters staff. In times of high employment such as the present, it is not to be expected that the conduct of the employment service at the national level will constitute a major activity of the Society as many men who are looking for a change apparently have no great difficulty in locating locally. The National Office, however, considers this a most important activity and is willing to serve all members of ISA as may be desired in this function.

This committee is supposed to have a member on it from each Section, who should also act as that Section's local employment committee chairman. As of this Spring, 29 Sections have a member actually appointed to this committee and 26 Sections are not represented. The attention of those Sections with no representative is invited to the fact that this representation is desired and will aid in forming one additional link of activity with the Headquarters Office.

Committee C-3 Intersociety Relations

The Chairman of C-3 is Everett S. Lee. This committee has had little activity over the past year. Its function is to promote cooperation with other technical societies and correspondence has been handled to achieve this objective. As an example of this, the A.I.E.E. is holding a special meeting in Philadelphia November 17-18, 1952 with Philadelphia Section sponsoring their Annual Symposium the following day, November 19.

Committee C-4
Public Relations

This is a new committee formed this year, to which Mr. Douglas M. Considine was appointed Chairman. Several additional members have been added to his committee and still others are to be added. The first results of this committee will be evident in the brochure entitled, "You and the ISA", available for the first time at this Cleveland Meeting. This is a membership promotion brochure to assist in outlining the objectives and the program of ISA to the prospective members and prospective Sections.

Another brochure slanted to obtain corporate memberships is now in preparation.

Committee C-5
Government Relations

Mr. Ralph L. Goetzenberger is Chairman. The function of this committee is to provide any desired liaison with the Government. The chairman has been actively supporting the interests of ISA with N.P.A. in Washington and is frequently called as a consultant to aid in the education of those men in the Government who have little or no background on instrumentation or automatic control, who have been employed to handle priorities and allocations in accordance with the C.M.P. In a similar capacity, the Munitions Board has at times sought his advice.

He has been active on the question of occupational definitions conferring with the Labor Department on this subject.

Committee C-6
Education

Professor Robert J. Jeffries, Chairman. This committee was entirely reconstituted this year. Professor Jeffries now has a membership of approximately ten men on this committee and he is actively pursuing the definition of a program and organization of the work for this committee. An important meeting of this committee is scheduled at the Cleveland Conference and it is anticipated that both the program and work on the program can be reported at the time of the next Annual Meeting.

Committee C-7
Historical

The Chairman of C-7 is Mr. L. M. Susany. A complete report has been promised by this committee for early consideration of the Executive Committee. Its Chairman has been handicapped by considerable illness but has advised that progress is now being made on his work.

General Report

The Executive Board has authorized this Vice President to appoint a Special Committee for Corporate Membership and with the receipt of the brochure and the formation of this committee, it is anticipated that considerable activity can be reported on this by the time of the next Annual Meeting.

PRESIDENTS REPORT

Continued from page 1269

vidual, must be given credit for the birth of the Society and for its guidance and growth during these first critical years. As Executive Secretary, he served in fact as General Manager, without compensation. He provided facilities, administrative skill and continuity in operations at the period when they were most needed. The Society's Annual Instrument Exhibit, under his capable management, has been a major source of income for the Society's operation. In recognition of his untiring work during his years of service as Executive Secretary of the Society, the Executive Committee has instructed the Manager to hang a picture of Mr. Rimbach in a place of honor in the National Office of the Society. Although he has resigned as Executive Secretary, Mr. Rimbach will continue to serve the Society as Exhibit Manager.

Under the new By-Laws, there are four Standing Committees in the President's Division. The Society Structure on Planning Committee, Mr. Nelson Gildersleeve, Chairman, is considering several matters involving long-range policies of the Society. Probably the most important matter is the future of the ISA Journal and the Society's publication policy in general. This is a complicated problem and the Committee is not yet ready to report its recommendations.

The Nomination Committee, G. F. Akins, Chairman, has selected the following slate of nominees for the 1953 officers of ISA:

For President
Porter Hart, Houston Section

For Vice Presidents
Warren H. Brand, Oak Ridge Section and J. M. Ribble, Panhandle Section

For Treasurer
J. T. Vollbrecht, New York Section

For Secretary
W. A. Wildhack, Washington Section

The Constitution, Rules and Procedures Committee, Mr. R. L. Galley, Chairman, in addition to consideration of proposed amendments to the Constitution and By-Laws, is engaged in bringing up-to-date the ISA Code on Procedures which was prepared in 1948 and has not since been revised.

One of the interesting accomplishments of the Instrument Industry Committee, Charles L. Saunders, Chairman, is the Panel Forum on "Frontiers of Instrumentation" which will be held during the Cleveland Conference. Gerard Piel, publisher *Scientific American*, Lawrence P. Lessing, member of the board of editors, *Fortune*, Harry Lee Waddell, editor *Factory Management and Maintenance*, Sydney Self of the *Wall Street Journal*, with David Dietz, science editor of *Cleveland Press*, as moderator, will express their views and answer questions on the challenge which technological progress is making to the users and producers of instruments and automatic controls.

This Forum of eminent scientific editorial writers and publishers is one of several "firsts" which promise to make the Cleveland meeting outstanding. Both the Exhibit and Technical Conference at this meeting will be the largest in the history of the Society. There will be 199 exhibitors, and the exhibits will occupy 26,000 square feet of floor space, in comparison with 133 exhibitors and 22,240 square feet of floor space at Houston. A total of 100 technical papers will be presented in Cleveland, the largest number of papers thus far presented at any ISA Technical Conference. The subject matter covers several new fields of instrumentation. In addition to sessions on Instrumentation for Production Processes, Testing and Analysis and Instrument Operation and Maintenance, which have been held at previous conferences, there will be new sessions on Radiation, Aeronautic, Medical, and Geophysical Instrumentation. The Instrument Maintenance Clinic, which has been so highly successful in previous meetings, will be held again in Cleveland. A new Clinic on Analysis Instrumentation will be initiated at this meeting. This Clinic, in which nine instrument manufacturers will participate, will consist of a lecture and demonstration course on complex analytical instruments. It is designed particularly for technicians, chemists, physicists, and engineers.

The Executive Board held four meetings during the past year. The several officers of the Society will report individually on transactions and developments of particular interest which fall within the spheres of their respective responsibilities. A few items of general interest may appropriately be mentioned here.

The ISA Film on Principles of Automatic Control has been a financial and educational success. In view of this fact, the Educational Committee has been asked to investigate other subjects which might be suitable for similar films.

An item of particular interest is the decision to hold an International Instrument Congress and Exposition in 1954. The First International Instrument Congress and Exposition will celebrate the Tenth Anniversary of the Instrument Society of America. The Congress and Exposition has been scheduled for the Commercial Museum and Convention Hall, Philadelphia, Pennsylvania, September 14-24, 1954. It is expected that this meeting will attract a world-wide audience from manufacturing companies, research laboratories, educational institutions and government bureaus—the largest number of instrument buyers and users ever assembled in one place.

To start the ball rolling, announcements of the First International Congress and Exposition were made in March at luncheon meetings held in Washington and New York which were

attended by official representatives of foreign countries and of many scientific and technical societies. The response to the initial announcement has been most gratifying. It is now estimated that at least 100,000 square feet of exhibit space will be required. The technical papers to be presented at the Congress will run into the hundreds because of the large number of cooperating societies which hold their meetings in conjunction with the Congress. Thus far twenty societies have indicated their intentions of cooperating. In the case of several societies, their meetings will be international in scope. It appears, therefore, that the First International Instrument Congress is well on its way.

The schedule of the ISA Annual Instrument Conference and Exhibit for the next five years is

1953 Chicago
1954 Philadelphia
1955 Los Angeles
1956 Detroit
1957 New York

A serious problem of the Society has been the indoctrination of new Officers and Committee Chairmen with a thorough understanding of the duties which their respective jobs entail and the transfer to them of the cumulative experience of their predecessors. During the past year, progress has been made on this problem by establishing clear statements of the duties and functions of each Officer and Standing Committee and by the preparation of a Manual of Operations for each Officer and Committee Chairman which will be handed on each year to the newly-elected or appointed officials. It is expected that each person will modify or add to the Manual on the basis of his own experience so that they will always reflect best current practices and will become increasingly valuable as procedural guides.

The past twelve months has been a period of substantial accomplishment, steady growth, and expanding horizons. Looking to the future, it seems certain that the Society will continue to grow. The instrument industry is still in its infancy. As the industry grows, unquestionably ISA will grow correspondingly. Opportunities for effective contributions to the Science of Instrumentation in the various fields in which the Society is now operating will continue to increase. In addition, there are many new and fertile fields, such as Computers and Instrumentation for Automatic Handling of Data, into which the Society should logically expand. In the light of the progress which the Society has made during the past years and of the opportunities which we can see in the future, it is difficult to have anything other than great optimism for the future of the Society.

To the newly elected officers and to those who continue in office, I extend my best wishes for outstanding success. To my fellow officers, committee chairmen and members, and to the many other persons who, by their faithful and diligent efforts have produced the accomplishments of the past year, I express my sincere appreciation and thanks, both personally and on behalf of the Society.

ARNOLD O. BECKMAN

Secretary's Report to the Council

When the new constitution of the ISA was officially adopted eliminating the office of Executive Secretary for the Society, Richard Rimbach submitted his resignation to the Executive Board at its meeting December 2, 1951, asking it to be effective December 8, 1951. The Executive Board regretfully accepted the resignation of Mr. Rimbach with an expression of deep appreciation for his untiring work during his years of service as Executive Secretary. It was also moved that the Society Manager be instructed to hang a picture of Mr. Rimbach in a place of honor in the National Office of the Society.

The writer of this report was appointed to serve as ISA Secretary until his successor is duly elected and takes office. At the Council meeting September 8, 1952, a Secretary to the Executive Board will be elected by the Council.

At the Executive Board meeting July 18, 1952, Dr. A. O. Beckman reported that the National Research Council, in an action dated April 16, 1952, had approved ISA as an Affiliate Member. It is the understanding of the Secretary that never before has such a young society received such an invitation from this group, and the Executive Board accepted this invitation to affiliate with the National Research Council.

A brief summary of the Organization is given below for the benefit of the delegates and members of the Society who are not acquainted with the National Research Council.

At the request of President Wilson, the National Academy of Sciences, under its Congressional Charter, organized the National Research Council in 1916, as a measure of national preparedness. The Council was continued as a permanent Organization after the war in accordance with an Executive Order.

The purpose of the Organization is the promotion of research in the physical and biological sciences, and the encouragement of the application and dissemination of scientific knowledge.

Membership of the organization is about 200 members, composed essentially of representatives of national scientific and technical societies, representatives of governmental and other research institutions. Membership is by election and appointment by the President of the National Academy of Sciences. There are no dues.

A library is maintained by the Council and contains many publications of other learned academies and scientific institutions of the world, and to a limited extent reference works.

The Council expends large sums each year, in varying amounts, for its administration; for specially designated research purposes; for the support of research fellowships; for general conferences and meetings of its committees; and for special undertakings, by contract, at the request of governmental agencies.

The funds for its administrative expenses are derived mainly from an endowment given by the Carnegie Corporation. The Council also receives other gifts and "grants in aid."

A number of publications are sponsored by the National Research Council. These include the National Critical Tables and numerous bulletins containing advanced technical papers and results of the council's scientific survey.

Your Secretary wishes to express appreciation to the Society Manager for his active assistance in recording the meetings of the Executive Board, and the promptness in the handling of applications for new sections, foreign memberships, and membership-at-large through the Sections and Membership Committee. He also wishes to thank the temporary chairman of this committee, M. S. Jacobs, for the promptness with which he corresponded with the Secretary so that the Executive Board could be polled by mail for the proposal and acceptance of new members.

Porter Hart, Secretary

Just Published

Industrial Instrument Training Course Outline

Prepared by ISA Subcommittee on Instrument Mechanic Training under chairmanship of George A. Larsen.

60 pages—heavy-paper bound

Prices per copy — $ .75 to members; $1.50 to others

Instrument Society of America, National Office

1319 Allegheny Ave., Pittsburgh 33, Pa.

Section Secretaries, Meeting Data and Programs

AKRON
Russell F. Marquardt, 1782 Tonawanda Ave., Akron 5, Ohio. Tel: ST-6865
Fourth Tuesday, Meeting 8:15 P.M., U. of Akron, Ayer Hall, Rm. 212-B.

ALBUQUERQUE
W. E. Bostwick, 700-C Washington St., N.E., Albuquerque, N. M.
First Monday, Meeting at 8:00 P.M., Mitchell Hall, Univ. of New Mexico.

ARUBA
J. L. Lopez P. O. Box 203, c/o Lago Oil & Transport Co. Ltd., Aruba, N. W. I. Tel. 2087.
First Tuesday, 7:30 P. M., Engr's Club.

ATLANTA
M. Virgil Davis, 357 Sixth St., N.W. Atlanta, Ga. Tel. EM. 3042
Fourth Friday, Meeting 7:30 P.M., Electric Bldg., Georgia Power Co.

BALTIMORE
G. B. Greer, 631 East 36th St., Baltimore 18, Md. Tel: CHesapeake 6879
Second Friday, Meeting at 8:00 P.M., Engr's Club of Baltimore.

BATON ROUGE
G. M. McCarroll, 1813 Edinburgh Ave., Baton Rouge 6, La.
Meeting monthly, L.S.U. Physics Bldg.

BOSTON
Stephen E. Lord, 60 Braintree Ave., Quincy 69 Mass. Tel: MA 9-1066
Fourth Wednesday, Dinner at 6:30 P. M., Meeting at 7:30 P. M., 99 Club, 99 State St.

CALIFORNIA
Gerald B. Miller, 4622 Halbrent Ave., Sherman Oaks, Calif. Tel: STate 43661
Second Wednesday, Dinner at 6:30 P. M. Meeting at 8:00 P. M.

CAROLINA PIEDMONT
L. Frank Lawrence, Minneapolis-Honeywell Regulator Co., 2400 Wilkinson Blvd., Charlotte, N. C., Tel: 5-4422
Second Friday, Dinner at 7:30 P.M., Meeting at 8:30 P.M. Cardinal Restaurant, Charlotte, N. C.

CENTRAL ILLINOIS
Thomas A. Carroll, 721 Hurlburt St., Peoria, Ill., Tel: 4-8909
Second Wednesday, Some dinner meetings at 6:30 P. M., Meeting at 7:30 P. M.

CENTRAL INDIANA
Norman Krone, 123 N. Grant Ave., Indianapolis, Ind. Tel: IRvington 5337
First Tuesday, Meeting at 7:30 P. M.

CENTRAL NEW YORK
H. G. Murray, 169 Durston Ave., Syracuse 6, N. Y. Tel: 9-9259
Third Monday, Dinner at 6:00 P. M., Meeting at 8:00 P. M.

CENTRAL OHIO VALLEY
J. C. Dilliner, 813 Winton Ave., Belpre, Ohio. Tel: Belpre 87596
First Tuesday, Dinner at 7:30 P. M., E.S.T., Hi-Way Grille, Rt. #2, about 3 miles south of St. Mary's, W. Va.

CHARLESTON
D. A. Cunningham, 5140 Washington Ave., S.E., Charleston, W. Va. Tel. 55403
First Monday, Dinner at 6:15 P.M., Meeting at 8:00 P.M., Kanawha Airport Terminal Bldg.

CHICAGO
Floyd E. Ertsman, Rm. 1420, Fisher Bldg., 343 S. Dearborn St., Chicago 4, Ill. Tel: WE 9-0686
First Monday, Dinner at 6:30 P. M., Meeting at 8:00 P.M., Hotel Shoreland.

CHINA LAKE
Beuhring W. Pike, 606-A Essex Circle, China Lake, Calif. Tel: 77782
Third Thursday, Meeting at 8:00 P.M., Michelson Lab, USNOTS, Conference Room.

CINCINNATI
E. J. Geiser, 3666 Hubble Rd., Cincinnati 24, Ohio Tel. Ja. 5618.
First Monday, Dinner at 6:30 P. M., Meeting 8:00 P.M., Engineering Soc. of Cinn.

CLEVELAND
M. M. McMillen, Thompson Products, 2196 Clarkwood Ave., Cleveland, Ohio
Second Wednesday, Dinner at 6:30 P. M., Meeting at 8:00 P.M., Cleveland Eng'r. Society, 2136 E. 19th St.

COLUMBUS
Kenneth I. Lea, Battelle Institute, 505 King Ave., Columbus 1, Ohio Tel: UN-3191,Ext. 247.
Third Thursday, Meeting at 8:00 P.M., Battelle Auditorium

CUMBERLAND
Clyde Babst, 225 Cecelia St., Cumberland, Md. Tel: 583-W
Fourth Wednesday, Dinner at 6:30 P. M., Meeting at 8:00 P.M.; Ali Ghan Shrine Country Club, Baltimore Pike.
Sept. 24, Subject: "Rocketry and Associated Instrumentation," by Dr. L. E. Morey, Hercules Powder Co., Allegheny Ballistics Lab.

DENVER
Karl F. Kent, Jr., 5030 Unatilla, Denver 11, Colo.

DETROIT
Ralph Hoxie, Basic Service Corp., 14016 Woodrow Wilson, Detroit 6, Mich., Tel: TO-88043
Third Wednesday, Meeting 8:00 P. M., Rackham Memorial Bldg., 100 Farnsworth, Detroit, Mich.

EASTERN NEW YORK
Robert W. Carter, Sterling-Winthrop Research Institute, Rensselaer, N. Y. Tel. Albany 5-6251 Ext. 262
First Tuesday, Meeting at 8:00 P.M., Siena College, Loudonville, N. Y. Optional Dinner at 6:00 P.M., Circle Inn, Lathams, N. Y.

GULF COAST
Harold Placette, 2440 Neches Ave., Port Arthur, Texas
Last Tuesday, Meeting at 7:30 P. M., Orange County Courthouse, Orange, Texas.

HOUSTON
A. Costa, 714 East 17th St., Houston 8, Texas.
Last Monday, Meeting at 8:00 P.M., University of Houston Library Building.
Sept. 29, J. L. Serrill, Leeds & Northrup Company will speak on "Infra-Red Gas Analyzer"

KANSAS CITY
J. C. Brous, 8827 Maiden Lane, Kansas City 5, Mo. Tel: HI 8556
First Tuesday, Meeting at 7:30 P.M., U. of Kansas City, Science Bldg., Rm. 106.

LAKE CHARLES
A. T. Clinger, Columbia Southern Chemical Corp., P. O. Box 900, Lake Charles, La.
First Wednesday after last Monday, Dinner and regular meetings at McNeese State College

LOUISVILLE
C. M. Bosworth, 5336 Westhall Ave., Louisville, Kentucky. Tel: FR 3494
First Monday, Meeting at 8:00 P.M., Seagram Auditorium.

MONTREAL
W. L. Toohey, Dominion Textiles Ltd., 710 Victoria Square, Montreal, Quebec

MUSCLE SHOALS
Atherton Hastings, Tennessee Valley Authority, Div. of Chemical Engineering, Wilson Dam, Alabama. Tel: Sheffield 3160, Ext. 6238
First Thursday, Meeting 8:00 P.M., TVA Chemical Engineering Bldg.

NEW JERSEY
Eliot R. Hill, 1125 Kensington Ave., Plainfield, N. J.
First Tuesday, Meeting 8:00 P. M., Essex House Hotel, Newark, N. J.
Oct. 7, Electrical Thermometry

NEW ORLEANS
W. H. Haney, 2927 Music St., N. O. 22, La.
No Regular Date, Meeting at 8:00 P.M.

NEW YORK
R. A. Hutcheon, 45-65 196th St., Flushing 58, N. Y., Tel: HAyside 9-5432
Third Monday, Dinner at 6:00 P. M., Meeting at 7:30 P. M., Midston House, 38th St. & Madison Ave.

NIAGARA FRONTIER
Duran L. Hagler, 214 E. Delavan Ave., Buffalo, N. Y., Tel: ELmwood 1258
Dinner at 6:00 P. M., Meeting at 8:00 P. M., N. Y. S. Technical Institute, 1685 Elmwood Ave., Buffalo, N. Y.

NORTH TEXAS
R. E. Byers, 6000 Lemmon Ave., Dallas 9.

NORTHERN CALIFORNIA
Robert L. Norman, 351 42 St., Richmond, Calif. Tel: BE 2-0901
Third Monday, Dinner 6:30 P. M., Meeting 8:00 P.M., Spengers Grotto, 1919-4th St., Berkeley.

NORTHERN INDIANA
J. Baum Beckman, 7145 Wicker Ave., Hammond, Ind. Second Tuesday, Meeting at 7:30 P.M., Whiting Community Center, Whiting, Ind.

OAK RIDGE
George Ritscher, 113 Gorgas Lane, Oak Ridge, Tenn. Tel. 5-1084
First Wednesday, Meeting at 7:30 P.M., Ridge Recreation Hall
Oct. 1, Joint Meeting with American Rocket Society, Movies and Lectures on Instrumentation of Guided Missiles and Rockets

ONTARIO
John W. Huether, 311 Southerland Dr., Leaside. Ontario, Canada. Tel: HU-7114
Third Thursday, Meeting at 8:00 P.M. Friendship Hall, College St. United Church, Toronto

PANHANDLE
George W. Leggett, Box 1526, Phillips Chemical Co., Borger, Texas

PERMIAN BASIN
J. B. Jenkins, 509 South Ave. "C," Kermit, Texas. Tel: 3220
Second Tuesday, Meeting at 7:30 P. M., Gulf Oil Corp. Auditorium or Odessa College.

PHILADELPHIA
R. A. Trenner, Energy Control Co. Rm. 304, 3147 N. Broad St., Philadelphia 32, Pa. Tel: SA 2-7900
Third Wednesday, Meeting at 8:00 P.M., Bellevue-Stratford Hotel.
September 18, "Gadget Contest," Prizes to be awarded to local members.

PITTSBURGH
Dr. A. H. Peterson, Mellon Institute, 5th Fifth Ave., Pittsburgh 13, Pa. MAflower 1-1100
Fourth Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Roosevelt Hotel

PRESQUE ISLE
Edwin P. Schuwerk, 445½ Halley St., Erie, Pa. Tel: 2-3349
Fourth Tuesday, Meeting at 8:00 P.M., Community Center, East Lake Rd., Erie, Pa.

RICHLAND
J. R. Plee, 1309 Roberdeau, Richland, Wash. Tel: 5-8692
Second Wednesday, Meeting at 7:30 P. M., American Legion Hall

ROCHESTER
R. C. Schwarz, Jr., Foxboro Co., 1201 Granite Bldg., Rochester 4, N. Y. Tel: Hamilton 1468.
Fourth Tuesday, Meeting at 8:00 P.M., University of Rochester, Physics Lecture Hall.

SARNIA
L. J. Hall, 730 Talfourd St., Sarnia, Ont., Canada. Tel: EDgewater 2258.
Second Monday, 8:00 P. M., Y.M.—Y.W.C.A.

SAVANNAH RIVER
F. P. Ledford, Jr., c/o Field Project Manager, Ga.,
E. I. du Pont de Nemours and Co., Box 1[illegible] Augusta, Ga.

SOUTH TEXAS
H. C. Givens, La Gloria Corp., P.O. 637, Falfurrias, Texas. Tel: 122-W
First Wednesday, Meeting at 7:30 P.M.

SOUTHERN MICHIGAN
Lyle J. Draper, 2233 Oakland Dr., Kalamazoo, Mich.
Fourth Wednesday, 8:00 P. M., Dinner at 6:[illegible] P. M., Chicken Charlie's, Kalamazoo.

ST. LOUIS
W. G. Lee, 4710 Delor St., St. Louis 16, Mo. Tel: FL 8516.
First Wednesday After First Monday, Meeting at 8:00 P.M., Engineer's Club of St. Louis.

TOLEDO
P. H. Girkins, 418 Waggoner Blvd., Toledo 12, Ohio. Tel: LA 6505
Third Tuesday, Meeting at 8:00 P. M., Service Bldg., Toledo Edison Co.

TENNESSEE
James L. Williams, 2237 Bruce St. Kingsport, Tenn. Tel: 2079-L
Fourth Thursday, Civic Auditorium.

TULSA
A. J. Sesock, 845 South East Ave., Tulsa, Okla., Tel: 8-1112
University of Tulsa Campus, Petroleum Bldg.
First Monday, Meeting at 7:30 P.M.

TWIN CITIES
John L. Schmidt, 1879 University Ave., St. Paul 4, Minn., Tel: DR 0064
Fourth Tuesday, Dinner at 6:30 P.M., Meeting 7:30 P.M., Rm. 353, Coffman Memorial Union, U. of Minn.

WASHINGTON
Edward C. Lloyd, 2105 Spencer Road, Silver Spring, Md. Tel: SH. 9340.
Third Monday, Meeting at 8:00 P.M., P. E. P. Co. Auditorium.

WAYNE COUNTY
Clarence Ellison, 2443 15th St., Wyandotte, Mich. Tel: Avenue 2-4178
Third Monday, Meeting at 8:00 P. M., Casadei's Cafe, 400 Fort St., Detroit, Mich.

WILMINGTON
E. Avery Taylor, Taylor Instrument Co., Industrial Trust Bldg., Rm. 510, Wilmington. Del. Tel: 9814.
Third Tuesday, Meeting at 8:00 P.M. Harlan Public School, Wilm.

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Pictured above is one of the three-window displays which advertised the ISA Seventh National Instrument Conference and Exhibit held in Cleveland, September 8-12.

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The Neg'ator in Instrumentation

By Harry Mankonen*

Presented at the 1951 Conference of the I.S.A.

ALMOST two years of experience in neg'ator development, research and testing, and the solution of many application problems now allow a thorough study of neg'ator characteristics, design fundamentals as well as present and predictable applications. Differing in operating principle from conventional spring members, the neg'ator is characterized by properties which permits it to exert constant or controlled varying force through theoretically infinite deflection.

The characteristics of the neg'ator itself are considered first. The distinguishing physical and functional properties of the neg'ator and conventional spiral and extension springs are compared. Design formulae and operation of the three major forms of the neg'ator, (1) Extension member, (2) A-motor and (3) B-motor, are then discussed and illustrated.

Next, examples of the major existing applications of the neg'ator are examined in terms of form, function, field and type of mechanism and are illustrated by several representative designs. Additional applications now evolving through further experience with neg'ator are also included.

Characteristics of the Neg'ator

The neg'ator is a strip of flat spring material which has been given a curvature by continuous heavy forming at a constant radius so that, in its relaxed or unstressed condition, the neg'ator is in the form of a tightly-wound spiral. In Fig. 1 (a) the neg'ator is in its relaxed position and no part of the coiled spring stock is stressed by external causes. The outer end of the neg'ator in Fig. 1 (b) has been extended by a force P and the neg'ator, mounted for free rotation, has been partly uncoiled.

The force P at any extension is determined only by the work required to straighten the material in zone X from its coiled condition. Force P in Fig. 1 (b) will then remain constant with extension as long as each incremental length of neg'ator has an equal increase in stress as it is straightened. This condition represents a neg'ator having a zero gradient. The material in zone L has been put under stress

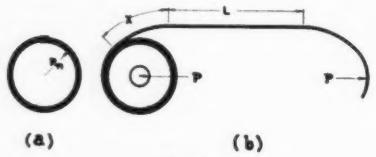


Fig. 1

and energy stored in it is proportional to the length of straightened material. The incremental stress increase occurring in zone X can be varied and a negative, positive or changing gradient obtained.

Neg'ator Compared With Spiral and Extension Springs

As and aid in visualizing the unique characteristics of the neg'ator and in evaluating its usefulness as a spring member, the engineer will find a comparison of the neg'ator with a representative spiral spring and extension spring helpful. Table 1 gives eleven characteristics which differentiate a zero-gradient neg'ator from a spiral spring, the most nearly similar conventional spring type.

Characteristics 1 and 2 represent the most important differences in operation. First, because stress is non-cumulative, a change in deflection of the neg'ator does not effect the stress of the material. Second, the force delivered by the neg'ator does not depend upon deflection. The other characteristics concern differences in anchoring methods, unstressed condition, method of charging, force development and delivery, stress, working range, space and intercoil friction.

Table 1 — Comparison of Conventional Spiral Spring and Zero-Gradient Neg'ator

SPIRAL SPRING	NEG'ATOR
1. Spiral spring is normally open to allow for winding.	1. Normally tight wound with each coil in close contact with adjacent turns.
2. Charged by winding to a tight spiral.	2. Charged by uncoiling outer end of spring.
3. Force developed increases as winding progresses.	3. Substantially full force at initial deflection.
4. Required force available at one point only.	4. Force substantially constant throughout entire deflection.
5. End of spring must be anchored for winding.	5. Spring must be mounted for free rotation of coil.
6. Force delivered (1) angularly. Or (2) by means of auxiliary member such as a drum, when it is delivered tangentially.	6. Force delivered linearly from center of coil to extended end of spring.
7. Spring is stressed as a unit by winding.	7. Spring is stressed sequentially by increments.
8. Cumulative stress limits possible deflection.	8. Non-cumulative stress does not limit deflection.
9. Working range is open spiral to tight wound.	9. Working range from tight spiral to straight or even reverse coiled.
10. Space required for expansion when unwound.	10. Space required for tight spiral only
11. Substantial losses due to intercoil friction during winding and unwinding.	11. No intercoil friction.

*Hunter Spring Company, Lansdale, Pa.

Presented at the Sixth Annual Conference of the Instrument Society of America, at Houston, Texas, Sept. 10-14, 1951.

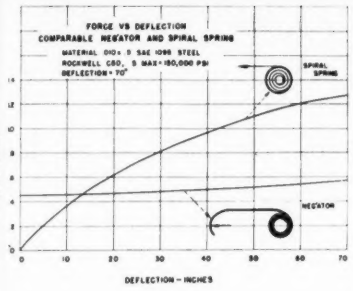


Fig. 2

The curves in Fig. 2 give a graphical comparison of the force-deflection characteristics of the neg'ator and a conventional spiral spring with auxiliary members which are required to convert its natural torque to lineal force. Both the neg'ator and the spiral spring are made from the same material, with identical dimensions and fatigue life, and both are designed for a 70-inch deflection. Through this deflection the force delivered by the spiral spring increases from zero to 1.25 pounds. For the same extension, the force output of the neg'ator increases from 0.465 pounds at initial deflection to 0.568 pounds at 70-inch deflection. The gradient of the spiral spring is 0.018 pounds per inch, while the gradient of the neg'ator is 0.00147 pounds per inch, or approximately 1/12 that of a comparable spiral spring.

The most common elastic member which exerts lineal force directly is the simple extension spring. Although the neg'ator and extension spring are not similar in appearance, they are comparable as single-unit spring members which exert a lineal force when deflected from their relaxed position.

The curves in Fig. 3 represent the force-deflection characteristics of a neg'ator with a minimum gradient and an extension spring which has been designed to have the lowest possible positive gradient and to occupy the same linear space as the neg'ator. The extension spring has been designed with an initial tension of one pound and the neg'ator has been designed for an initial force of one pound.

Both the neg'ator and the extension spring are deflected 10-inches (the limit for the conventional spring). Through this 10-inch deflection the neg'ator force increases from one pound to 1.004 pounds, which means that the neg'ator has a positive gradient of 0.0004 pounds per inch. In the same deflection range, a comparable extension spring increases in force from 1.0 pound to 6.4 pounds, a constant positive gradient of 0.540 pounds per inch. In this comparison the extension spring has a positive gradient 1,350 times that of the neg'ator.

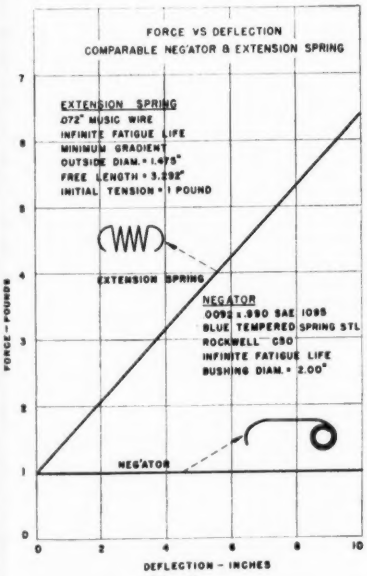


Fig. 3

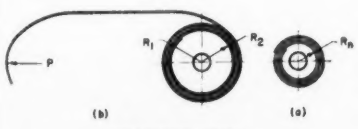


Fig. 4

EXTENSION FORM

Forms and Design Fundamentals

The three major forms of the neg'ator, which will be discussed here, are (1) extension member, (2) A-motor and (3) B-motor. Two other forms, the neg'ator clamp and the neg'ator clip, will not be discussed since their design and function are quite fundamental and are corollary to the basic neg'ator.

Fig. 4 shows the basic neg'ator used as an extension member. The material has been formed in manufacture so that each incremental length of neg'ator has an inherent natural radius of curvature R_n. Actually, only the inside coil of the relaxed neg'ator in Fig. 4 (a) has its natural curvature; the radii of succeeding coils are greater due to some expansion as the material coils upon itself.

The neg'ator in Fig. 4 (b) has been mounted upon a freely rotatable bushing of radius R_2 and has been partially deflected. Assuming that the radius R_2 of the mounting bushing is equal to R_n and that the build-up effect is negligible, the instantaneous force output of the neg'ator is given by the expression:

$$P = \frac{Ebt^3}{24R_n^2} \text{ pounds} \qquad (1)$$

where P is the force in pounds delivered by the neg'ator, b is stock width in inches, t is stock thickness in inches, and E is the modulus of elasticity of the material. Since the neg'ator material may be considered as a thin flat plate, the effect of Poisson's ratio must be incorporated in this formula for a more exact expression. The transverse stress in the material causes a curvature to take place across the width of the material, which produces a slight reduction in force output. Correcting Equation (1) for the effect of Poisson's ratio, we obtain

$$P = \frac{Ebt^3}{24R_n^2} \times 0.91 = \frac{Ebt^3}{26.4R_n^2} \text{ pounds} \qquad (2)$$

If R_n, the radius of curvature of the material, remains constant and, if the effect of build-up of succeeding coils is neglected, the force P will remain constant.

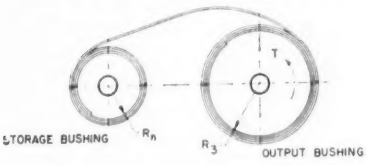
The change in curvature from R_n to infinite radius (material pulled out straight) occurs through the short zone X, Fig. 1) and since force P depends only on the work required to deflect the material through zone X from the radius of the outer coil, equation (2) is not correct when the radius of the outer coil exceeds R_n. Since the material in these outer coils has already been partially straightened by expansion, less work is required to completely straighten the material through zone X. Both Poisson's ratio and coil expansion, produced either by material build-up or a mounting spindle radius greater than R_n, are contained in the expression

$$P = \frac{Ebt^3}{26.4}\left[\frac{1}{R_n^2} - \left(\frac{1}{R_n} - \frac{1}{R}\right)^2\right] \text{pounds} \qquad (3)$$

For spring material of given width and thickness, force P depends only on the inherent neg'ator radius R_n and the radius R_1 of the outer coil. Unless there are a large number of coils mounted on the spindle, the effect of material build-up is negligible.

A-Motor Form

Fig. 5 shows a partially wound neg'ator A-motor. The energy stored by the neg'ator is delivered by a counterclockwise torque T about the axis of the output bushing. The torque is delivered as the neg'ator material runs



NEG'ATOR A MOTOR

Fig. 5

from the large output bushing to the small storage bushing. The radius of the storage bushing is indicated as R_n in Fig. 5.

The action of the A-motor can best be understood by referring to Fig. 6 where the neg'ator is assumed to consist of two extension members mounted, respectively, on the storage and output bushings. The spring material coiling on the storage bushing is shown in Fig. 6 (a) where the force P_n tends to coil the neg'ator around the bushing of radius R_n. Similarly, in Fig. 6 (b), the neg'ator mounted on the output bushing of radius R_1 has a retracting force P_1.

NEG'ATOR A-MOTOR OPERATION

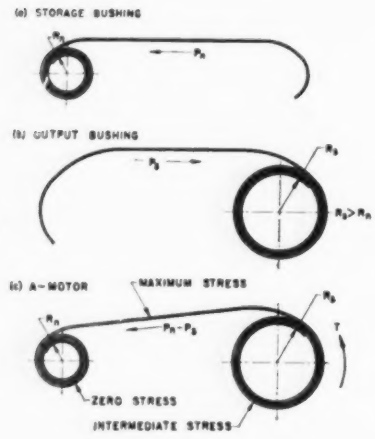


Fig. 6

If the hypothetical extension members in Figs. 6(a) and 6(b) are one and the same, the retracting force P_n will exceed P_s because the neg'ator is relaxed completely on the bushing with radius R_n and expanded on the larger bushing of radius R_s. By combining the conditions shown in Figs. 6(a) and 6(b), we have the condition shown at 6(c) where the resultant force P_n—P_s tends to transfer the neg'ator from the output bushing to the storage bushing.

The resultant torque T produced at the output bushing is given by the expression

$$T = \frac{Ebt^3R_s}{24}\left(\frac{1}{R_n} - \frac{1}{R_s}\right)^2 \text{ pound inches.} \quad (4)$$

In this equation no correction has been made for transverse crowning in the straightened section between bushings because no crowning is present when the material is either on the output bushing or on the storage bushing. Torque output is proportional to the output bushing radius R_s and is slightly reduced by build-up of material as the neg'ator coils from the output to the storage bushing.

In the A-motor the neg'ator material is fully stressed as it passes from the storage bushing to the straight portion and then reduced in stress as it goes from the straightened portion to the output bushing radius. Thus, as the neg'ator material deflects from the output bushing to the storage bushing, it is going from an intermediate stress through maximum stress and then down to zero stress in its relaxed position on the storage bushing.

B-Motor Form

In appearance, the B-motor in Fig. 7 is similar to the A-motor except that the neg'ator has been back-bent around the output bushing so that it is coiled opposite to its inherent curvature. Like the A-motor, the B-motor is charged by winding the neg'ator onto the output bushing, and delivers a counterclockwise torque T as the neg'ator runs onto the storage bushing. In the B-motor the neg'ator material goes from maximum stress on the output bushing through an intermediate stress in the straight portion to zero stress on the storage bushing.

NEG'ATOR B MOTOR

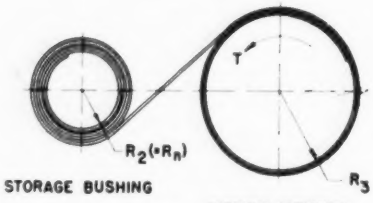


Fig. 7

The resultant torque T of the B-motor is given by the expression:

$$T = \frac{Ebt^3R^2}{24}\left(\frac{1}{R_n} + \frac{1}{R_s}\right)^2 \text{ pound inches} \quad (5)$$

As in the A-motor, no correction is necessary for transverse crowning. The torque output is proportional to the radius R_s of the output bushing. The neg'ator in the form of a B-motor makes maximum utilization of the material since it is used at maximum stress and stored at zero stress.

Neg'ator Applications

Instrumentation was among the first and presently is one of the most active of the 37 fields in which the neg'ator is being used. Table 2 lists 32 types of instruments in which the neg'ator functions to drive, control, retract and restore, load, remove backlash, indicate (expanded scale), counterbalance or close slots. Whatever its function the neg'ator is selected in each application for one or more properties: zero or controlled positive or negative gradient, large deflections (or number of revolutions), and minimum space requirements.

The three types of drive in which the neg'ator is used as the energy source are:

(1) A motor in which energy is stored by winding and released to produce required torque through a large number of revolutions.

(2) A torque mechanism with a pre-

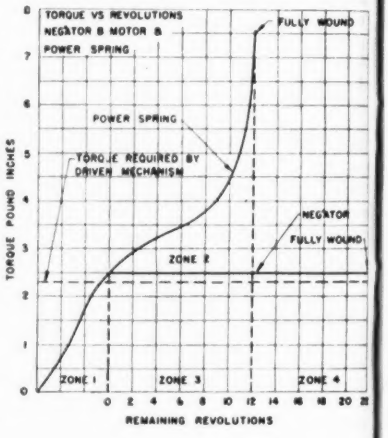


Fig. 8

Table 2 — Neg'ator Applications In Instrumentation

Function	Instrument
Drive	movie camera automatic camera still camera magnetic tape recorder slide projector clock timer gyroscope recording accelerometer chart
Retracting and restoring	recording machine slide projector carriage return photometer (cord reel) fire alarm system surveyor's chain steel tape rule air forces flight trainer
Loading	liquid level indicator dial indicator computer (cam follower) temperature control (cam follower) potentiometer (chart tensioner) rotating beam fatigue tester
Anti-backlash	computer temperature control (gear train)
Expanded scale	automatic camera altimeter radio receiver
Counterbalance	x-ray head
Slot Closure	bench micrometer
Control	vent valve

cise constant or low gradient designed to operate through a small number of revolutions.

(3) High torque source.

The B-motor is used in most of the instruments (Table 2) driven by a neg'ator, to obtain maximum useful energy output per pound of material. The curves in Fig. 8, compare the torque output of a typical power spring motor, similar to those used in many of these instruments, and a neg'ator B-motor using the same volume of spring stock. Both motors are designed to drive a movie camera requiring a torque of 2.3 inch-pounds.

In Zone 1, the torque delivered by the power spring motor is insufficient, the energy being wasted. The energy in Zone 2, released at excessive torque, must be dissipated by a governor. Zone 3 indicates the only portion of the total available energy of a power spring motor that is actually used to drive the camera. Compared to this, the useful energy delivered by the neg'ator B-motor is indicated by Zones 3 and 4. All of this is available to drive a camera through more revolutions at constant torque.

Some Avantages In Mechanism Design

As a drive for cameras and recorders, the large number of revolutions which characterize the B-motor result in increased footage of film exposure or recording per wind. In clocks, timers and chart drives longer timing cycles are obtained. Greater accuracy and simplified governing means are also possible because of the constant torque characteristics of the neg'ator. For example, the running time of a chart drive recently developed has been increased from 1 day to 8 days by replacing a power spring with a neg'ator B-motor in the same space. In another B-motor application, error of a 1-day clock was reduced almost 90 per cent from 4½ minutes each 24 hours to less than ½ minute. The larger number of revolutions of the B-motor permitted the designer to eliminate much of the gearing.

Very high torques and maximum work per unit volume are obtained with the multiple B-motor (Fig. 9), which consists of radially arranged storage bushings with neg'ator connected to a common output bushing. Multiple B-motor torque is equal to the sum of the outputs of each neg'ator.

MULTIPLE NEGATOR B MOTOR

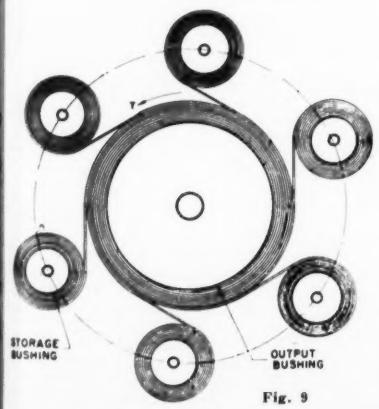


Fig. 9

In the control field, the neg'ator can be used for sensing, transmitting or actuating and may combine any of these functions.

Incremental adjustment of position can be readily attained with a very low gradient A-motor in which the controlling and controlled elements are each mechanically connected to respective A-motor bushings. A large number of turns in the controlling element results in only a small change in torque. By converting torque to force at the bushing connected to the controlled element, very small changes in position can be made with high precision. This is illustrated in Fig. 10. In this application, the neg'ator replaces high ratio transmission systems.

INCREMENTAL FORCE ADJUSTMENT MECHANISM

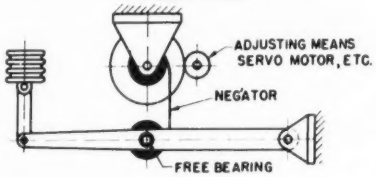


Fig. 10

Use in Automatic Control

An automatic control system is often required to exert force at either end of a range while having a neutral zone between the two extremes. The energy stored in the neg'ator is released at the extreme of the neutral zone to compensate for or amplify a deviation.

One form of a neg'ator control device is shown in Fig. 11. The center of the neg'ator is attached to the fixed housing and when extended lies between the housing and the rotating member as shown in Fig. 11(b). If the whole movable member is rotated in either direction until one end of the neg'ator coils on a spindle (mounted in the movable member) as shown in Figs. 11(a) and 11(b), a force P is developed which drives the movable member further in the direction of initial motion. A similar arrangement can be made to provide a lineal force output with a sliding movable member. In the above, the length of the neutral zone is a function of design and either may be used unidirectionally.

The neg'ator control device functions as a sensing and actuating element in a vent valve on volatile liquid storage tanks. The neutral zone of travel of a float corresponds to the permissable variation in internal tank pressure. Pressure changes caused by minute temperature variations require full venting to compensate rapidly for slightest deviation from safe pressure limits. The full force of the neg'ator

ZERO & TWO DIRECTIONAL TORQUE MECHANISM

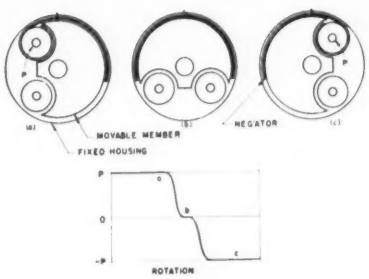


Fig. 11

is exerted to open the vent valve as the float's position passes the neutral zone bounds. The neg'ator returns to its neutral condition where it exerts no torque on the sensing member, when the float is again in a position corresponding to safe internal pressure.

Use for Retracting or Restoring Functions

The retracting and restoring function of the neg'ator is to return a displaced element to a standby position Retraction by the neg'ator may be lineal, as in the carriage return (Table 2) or angular as in the photometer cord reel. The surveyor's chain, cord reel and tape rule are similar applications in which one or more neg'ator B-motors retract an extended chain, cord or tape for storage. The design of a neg'ator system in these applications permits extensions not possible with any other system and yet provides proper torque throughout retraction as required by changing load.

In Fig. 12, the B-motor retracts a 50-foot steel tape through a planetary drive system. The planet gear on the output bushing at the right engages the sun gear fixed to the center of the housing and the B-motor drives itself and the tape drum assembly. Because the load on the drive system increases with extension of the tape, a slightly

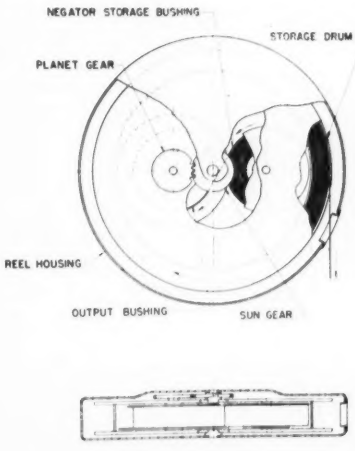
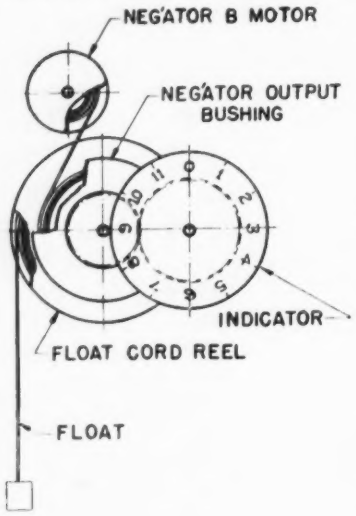


Fig. 12 PLANETARY DRIVE MECHANISM

positive gradient B-motor was specified.

Use as a Loading Device

Functioning as a loading device (Table 2) the neg'ator replaces dead

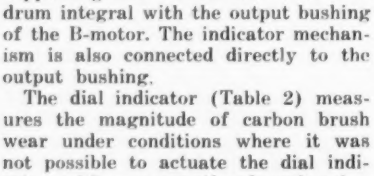


LIQUID LEVEL INDICATOR

Fig. 13

weights in the liquid level indicator and dial indicator. In the liquid level indicator Fig. 13, a neg'ator B-motor functions as a mechanical counterweight and eliminates the excessive space requirements and undesirable inertia effects of dead weights. The cable supporting the float is wound onto a drum integral with the output bushing of the B-motor. The indicator mechanism is also connected directly to the output bushing.

The dial indicator (Table 2) measures the magnitude of carbon brush wear under conditions where it was not possible to actuate the dial indicator with a conventional spring because the spring gradient affected the load on the brushes. As is common in the design of dial indicators in which



DIAL INDICATOR

Fig. 14

variation in spring loading affects measurements, a dead weight was substituted but was found to be impracticable because of vibration in the test fixture and space limitations. A neg'ator is now used, as in Fig. 14, to provide a constant force over full operating range.

In cam followers, it has been found that the neg'ator has a distant advantage over other types of loading members. The neg'ator provides a constant load on the cam independent of change of cam radius. Regardless of deflection, storage space does not exceed the size of the relaxed neg'ator. Full-range travel is obtained with minimum safe load, which reduces friction and consequent wear. Thus, simplification and economy of design is achieved along with improved accuracy and sensitivity.

Other Important Applications

An anti-backlash device is used to insure that all components of a system respond immediately to a change without lag. The goal of the designer is to accomplish this with a minimum constant load on the system. Either the A-motor, B-motor or extension membed may be used to prevent backlash in recording drums, pen carriages, gear trains and other transmission systems.

In gear trains, for example, the B-motor provides constant loading through many revolutions as compared with considerable load increase of the spiral spring through very limited rev-

ANTI-BACKLASH APPLICATION

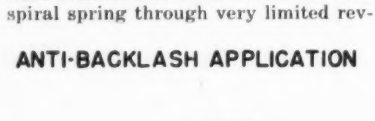


Fig. 15

olutions. The A-motors or extension member prevent backlash in lever, crank and slide mechanisms by continuously loading the systems in one direction. A positive gradient A-motor can compensate for changing moment arms in such devices. Examples of the above are illustrated in Fig. 15.

The neg'ator A-motor is a means of obtaining an expanded scale of immensely greater length than any other system can provide and usually requires much less space. In Fig. 16 a perforated neg'ator is mounted on two bushings of equal diameter and is metered by a sprocket. The balanced tension insures accuracy. The absense of torque on the metering system, due to balanced tension of the A-motor, provides greater sensitivity and hence improved accuracy. Calibration is usually printed directly on the neg'ator surface.

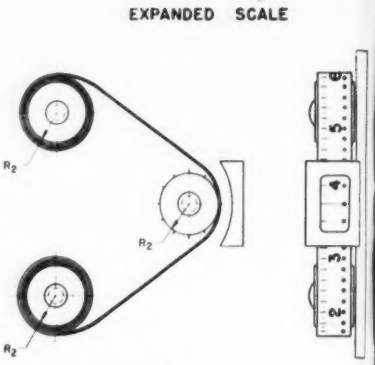


Fig. 16

Counterbalancing is a major consideration in the design of instruments and test equipment which have heavy parts or sections which must be moved frequently. In chemical processing, for example, float controls, prover bells, and scales and weighing devices are counterbalanced so that a shift in position may be accomplished with little effort. Counterbalancing is provided by the neg'ator as a mechanical counterweight replacing a dead weight and eliminating the need of space for travel. Neg'ator extension members and B-motors are used either singly or in parallel for large deflections and accupy minimum space.

Illustrating its application as a slot closure, the neg'ator closes a gap between horizontal v-ways on a precision bench micrometer. The neg'ator is coiled on a free-running bushing in the movable head and the outer end is attached to the fixed head of the micrometer. As the head moves in the slot, the neg'ator rolls and unrolls to cover the gap. There is no sliding friction and the force required to move the micrometer head to any point in the slot remains constant.

Conclusions

Summarizing, the neg'ator is basically a zero gradient spring capable of being used as an extension member and as a motor, the design being dependent upon the application. As an extension member, its deflection is almost unlimited. As a motor, it makes efficient use of all the energy stored in it. The various applications mentioned in this paper have been actually used by various manufacturers in their development, test and production programs.

The use of the neg'ator is limited only by the imagination of the designer. The intent of this paper has been to present the neg'ator in form, function and application to the instrument designer and manufacturer to acquaint him with its possibilities. From the facts presented, it can be concluded that although the *neg'ator* has been widely used in instrumentation, there are still innumerable applications where its unique characteristics can be advantageously employed.

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History and Operation of Positive Displacement Gas Meters

By WILLIAM F. CONNOR, Southern California Gas Company

OF THE many gas meters developed through the years, two types stand out—the wet-type and dry-type positive-displacement gas meter. Because its liquid seal has to be checked often and liquid added when necessary, the wet-type meter is not practical for domestic measurement of gas; it is used mostly in laboratory work or on jobs where constant checking is possible. For this reason, except for a brief history of wet and dry types of positive-displacement gas meters, this discussion is confined to domestic dry-type positive-displacement gas meters. The large industrial-type meters are built on the same principles as the small domestic-type meters.

History

Before 1815, gas was sold by contract on an estimated consumption. As gas was used only for lights, a customer was billed on the number of lights he had in the house. This proved financially unsound for the gas companies because people left lights on night and day, wasting about 70 percent of the gas. Gas companies soon learned that in order to be successful, they would have to find some way to measure the gas.

From 1815, when Samuel Clegg invented the first practical gas meter, to 1844, when Messrs. Croll and Richards invented the first practical dry-type gas meter, the wet-type positive-displacement gas meter was used generally for domestic service. This type of meter has never been superseded in accuracy; even today most laboratories have wet test meters for accurate measurement of small amounts of gas. Companies soon discovered that wet meters for domestic service were not too satisfactory because it cost too much to manufacture and maintain them, and climate affected the liquid seals.

John Malam developed the first dry-type gas meter in 1820. It had six diaphragms connected to a hollow shaft and was enclosed in a tin case. The diaphragms were controlled by a valve which resembled the rotating valve in some modern meters. This was an experimental meter and was never used.

The first gas meter made in the United States was produced by Samuel Hill at Baltimore in 1832. The same year in Baltimore, John Rogers, under the supervision of John M. Slaney, made a gas meter of similar design. These men are credited with being the founders of the gas-meter industry in this country.

In 1833, Bogardus invented a one-diaphragm meter and, in 1836, a two-diaphragm meter. Although a great deal of money and labor were spent trying to perfect these meters, neither type was used to any extent. In 1836, several meter companies consolidated and became the American Meter Company, one of the major meter companies of the present day.

In 1844, Messrs. Croll and Richards invented a two-diaphragm slide-valve meter which was accurate and regular in its action. The main ideas and the principle of this meter have remained unchanged up to the present day. Several years later this meter was perfected by Thomas Glover and is now generally referred to as the "Glover two-diaphragm slide-valve meter." The mechanical principles used in this meter were so sound and simple that the meter is still one of the two preferred types for gas measurement in domestic meters.

By 1859, the dry meter had taken the place of wet meters for domestic service. There was much effort expended in attempts to improve the dry meter, including the round three-diaphragm type, the rotary valve, the piston- or plunger-type diaphragm, and modified case forms. However, the exhaustive endeavor to improve domestic gas measurement proved only the soundness of the Glover-type dry displacement meter, and established its merits as far as accuracy, reliability, manufacturing costs, and maintenance costs were concerned.

In 1868, two brothers, P. H. and F. M. Roots of Connersville, Indiana, attempted to develop a two-impeller-type water wheel as a substitute for the undershot water wheel. They were not very successful in these early attempts, but out of their efforts came the rotary positive-displacement-type meter for gas measurement. The first meters were used to measure liquids, but years later it was realized that this type of meter could measure gas as well as liquid, and in 1922 a number of gas meters of the two-impeller rotary displacement type were installed in manufactured-gas plants to measure the plant output. This proved so successful that in a short time this type of meter was used almost universally for station metering. As natural gas became available in industrial centers, the meters were used for measuring large industrial loads, transmission-line service, and city gate measurement. Today they are

October Meeting: Thursday, the 16th, Rio Hondo Country Club, Downey, Calif.

Feature: "Rupture-proof Bellows Type Orifice Meters," by A. I. Thompson, Barton Instrument Corp.

Presented at the May 15, 1952 meeting of the Southern California Meter Association.

in demand for high-capacity positive-displacement measurement that is beyond the limits of other large, industrial positive-displacement meters.

In the early 1880's, George Westinghouse, great American inventor and engineer, discovered natural gas on his property and developed a method for conveying natural gas through pipes for long distances. This made possible the extensive use of gas for homes, mills, and factories. Realizing the need of a meter to measure large quantities of gas, he invented the Westinghouse meter. This meter is still used in the United States by the thousands, even though it is no longer manufactured. Its weakness was the same as other wet-type meters—it could not be used economically on all jobs and its maintenance was too costly; if the liquid seal was not kept up to its proper level it would go slower, and in time the liquid would be below the diaphragm compartment and the gas would go through the meter without registering. A few years later Mr. Westinghouse joined with the Pittsburgh Meter Company and the Equitable Meter and Manufacturing Company, both of Pittsburgh. The Equitable meter at that time was a 5-diaphragm meter.

The Sprague gas meter was invented by Henry H. Sprague of Bridgeport, Connecticut in 1900. Basic patents were granted in 1903. In 1907, the original #1 Sprague meter was improved considerably and called the #1A Sprague meter to distinguish it from the earlier #1 type. This was the start of the three-chamber-type iron-case meter.

The Emco iron meter was developed by the Equitable Meter Company about 1910 to meet the metering needs of the natural-gas industry for an improved iron meter. It fast displaced the Equitable 5-diaphragm meter. About 1917, the design was changed somewhat to meet the needs of manufactured-gas systems.

In 1927, the Pittsburgh Meter Company and the Equitable Meter and Manufacturing Company merged to form the Pittsburgh Equitable Meter Company. Through the years, numerous subsidiaries, serving varied industrial fields, were acquired. In order to have a name that more accurately reflected the broad manufacturing activities of the company, the manufacturing of meters being only one part of its output, the name was changed to the Rockwell Manufacturing Company in 1945.

Two other meter companies, little known on the West Coast, are the Cleveland Meter Company of Cleveland, Ohio, and the Superior Meter Company of Brooklyn, New York.

From 1900 to the present, some of the best engineers in the country have devoted their time toward improving the Glover-type domestic gas meter. The meter-industry experience between 1859 and 1900 had convinced them that this 4-compartment meter would be hard to beat, and that their best bet is to improve the original type. This type is used by all the companies with the exception of the Sprague Meter Company, which uses a 3-chamber type.

Before 1900, gas was used mostly for lighting, with the result that low-capacity meters were used. Around the turn of the century people began to use it for cooking and heating. Later, it was used for refrigeration and air conditioning. This called for high-capacity meters that could measure this increased load.

Diaphragms

Meters with leather diaphragms use the finest sheepskins that are available. Early English meters had diaphragms that were made of Persian sheepskins. Meter companies in the United States import their sheepskins from New Zealand because it is a little finer grained and is free of scars. Sheep roam free in New Zealand, with no barb-wire fences to injure their skins and produce scars which break down and cause holes if they were used to make meter diaphragms.

Synthetic diaphragms also are being used with such success that more and more companies are starting to use them. Undoubtedly they will continue to compete with the leather type.

Features

The dry-type positive-displacement gas meter is a most convenient and reliable type of registering apparatus for long periods. You will have a difficult time finding another instrument that measures accurately for 10 years under all kinds of conditions such as heat, cold, action of gas, constant running 24 hours a day, and wide load fluctuation. When once set, a gas meter usually remains in the same place for years without any attention except for the monthly visits by the Meter Reader.

Most of the troubles we have with modern meters are not functional but are caused by poor workmanship, overloading, too much pressure, turning the gas into the meter too fast, connecting meters on crooked sets, setting them on the ground where they rust quickly, setting them in the open, rough handling, dropping, and other things that cannot be blamed on the working principle of the meter itself.

Principles

The positive-displacement gas meter is usually compared with the reciprocating steam engine. The design is similar; the meter might have been influenced by the steam engine which was invented by James Watt a few years earlier.

When explaining the principle of measurement, I like to compare it with the measurement of a liquid from a cask through a spigot into a quart measure. Each time the quart measure is filled, the spigot is closed and a valve controlling an opening in the bottom of the measure is opened. When the measure is empty, the valve is closed and the spigot is opened. This process is repeated, and the number of measures emptied is counted to determine the quantity of liquid drawn from the cask.

In order to obtain accurate measurement, the following conditions must be filled: (1) The measure must hold exactly one quart, (2) while the measure is being filled from the spigot, no liquid must be allowed to escape from the measure into the receptacle for the measured liquid, (3) after the measure has been filled, the spigot must be completely closed before the measure starts to empty, and (4) an accurate count must be obtained of the number of measures which are emptied.

The positive-displacement gas meter contains four of these "measures," or chambers—some filling while others are emptying, but always fulfilling the above conditions. Each of these measures is the difference between the capacity of the chamber at the limit of its filling stroke and the capacity of the chamber at the limit of its emptying stroke. The length of these strokes is adjusted accurately to make the difference in chamber capacities equal to a definite volume. The mechanism is constructed so that the number of times each measuring chamber is filled and emptied is registered by indicating the total volume in cubic feet on the index which is operated from the crank rotated by the movement of the diaphragms.

In the 3-compartment meter, the same conditions are true except that the center compartment is the equivalent of "two quarts." This meter has a single valve which rotates on a white-metal seat and uncovers one or two of the chamber ports to the inlet gas, simultaneously opening the other chamber or chambers to the outlet port through the concave center of the valve. The construction of the double-throw crank is such as to make one crank lead the other by an angle of a little less than 90 degrees. The action resulting from this arrangement is rather complex because at certain periods of the cycle both diaphragms are moving outward, at other times both are moving inward, and sometimes one is moving outward while the other is moving inward. The action in the 4-compartment type is somewhat similar but is easier to visualize than the 3-compartment type. Following is the action that takes place when a meter is operating:

The motive power is the difference in pressure of the gas at the meter inlet and outlet. No motion can take place unless this pressure differential exists. As the valves are at right angles to each other and connected to a single crank, there can be no position when both valves are on dead center. As soon as the pressure at the meter outlet is reduced by turning on some gas-burning appliance, the gas pushes one or the other of the two diaphragm in or out, depending on which port happens to be open to the outlet at the time the gas is turned on.

To illustrate this action, assume that

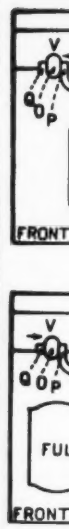

Fig. 1. operating

the gas and dia shown i connecte back va (O). Th to the gas ente it out, f ber thro (V_1) to valve (point of phragm ment.

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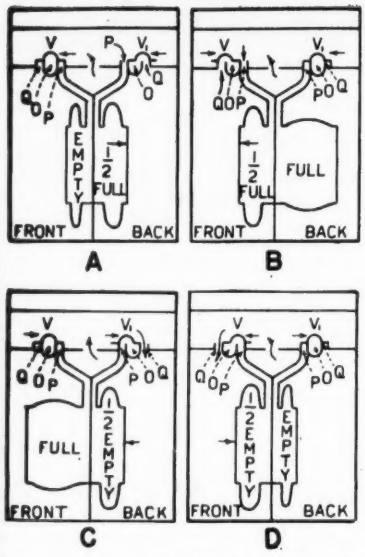

Fig. 1. Valve and diaphragm relations when operating.

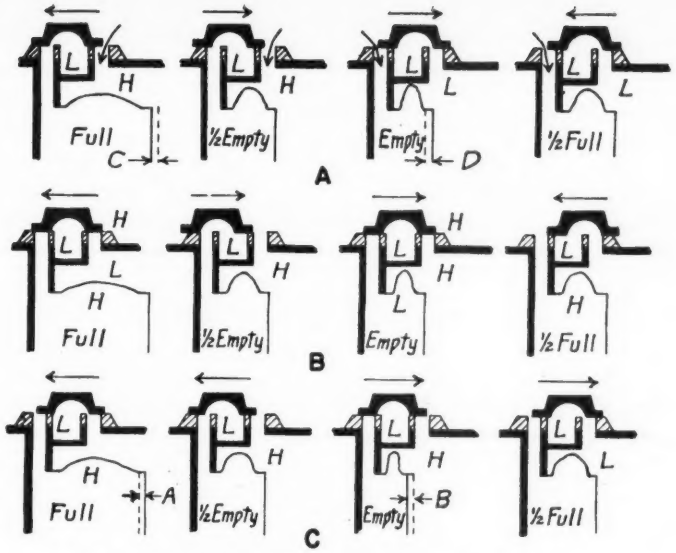

Fig. 2. Valve cut-off conditions. A, early; B, normal; C, late.

the gas is turned on when the valves and diaphragms are in the positions shown in Fig. 1A. The back chamber is connected through the port (Q) of the back valve (V_1) to the meter outlet (O). The back diaphragm is also open to the pressure of the inlet gas. The gas entering the back diaphragm pushes it out, forcing the gas in the back chamber through port (Q) of the back valve (V_1) to the meter outlet (O). The front valve (V) is on dead center, or at its point of cut-off sealing both the diaphragm and the diaphragm compartment.

The relative position of the valves is shown when the back valve (V_1) has reached its dead center position (Fig. 1B), shutting off the back diaphragm from the inlet gas and the back diaphragm compartment from the outlet. But while this has been occurring, the front valve (V) has moved to allow inlet gas to enter the front diaphragm, forcing the gas in the front diaphragm compartment through the front valve port (Q) to the meter outlet (O). Thus, when the back valve is in a position that prevents the back diaphragm or back diaphragm compartment from supplying gas to the meter outlet, the front diaphragm is moving outward, forcing the gas out of the front diaphragm compartment.

Fig. 1C shows the next position in the cycle of meter action. The front diaphragm has filled and the front valve (V) has moved back to its dead center position. The back valve (V_1) has reached the end of its inward stroke and the inlet gas is now entering the back diaphragm compartment, pushing the gas from the back diaphragm through the port (P) of the back valve to the meter outlet through (O). Fig. 1D shows the fourth position in the cycle. The inlet gas has pushed the back diaphragm to its "empty" position, at which point the back valve (V_1) shuts off the inlet gas, preventing further motion. The front valve (V) meanwhile has moved "in" to the end of its stroke and the gas now enters the front diaphragm compartment, forcing the gas out of the front diaphragm. The next step in the cycle brings us back to the valve and diaphragm relations shown in Fig. 1A.

The positions of valves and diaphragms shown. are called the points of cut off, when the tangent is rotated in a clockwise direction. At all other positions of the valves, both diaphragms and both diaphragm compartments are either receiving or delivering gas.

Fig. 2 shows four relative positions of valve and diaphragm under three conditions of valve cut-off—early, normal, late. In the early condition (Fig. 2A) the valves cut off too soon and the diaphragm stroke becomes shorter than normal; "C" represents restricted movement of disk at end of normal filling stroke due to drop of pressure inside and increase of pressure outside of the diaphragm before it has completed its normal stroke; "D" represents restricted movement of disk at end of normal emptying stroke due to drop of pressure outside and increase of pressure inside of the diaphragm before it has completed its normal inward stroke.

In the normal condition (Fig. 2B) the valves cut off properly and the measurement is correct.

In the late condition (Fig. 2C) the valves cut off too late and the diaphragm stroke becomes longer than normal; "A" represents movement in excess of normal filling stroke due to continued high pressure inside and continued low pressure outside of the diaphragm after the diaphragm has finished its normal outward stroke; "B" represents movement in excess of normal emptying stroke due to continued high pressure outside and continued low pressure inside of the diaphragm after the diaphragm had finished its normal inward stroke. "H" indicates high pressure existing in space so marked. "L" indicates low pressure existing in space so marked.

Mechanical Measurements by Electrical Methods

By HOWARD C. ROBERTS

Special Research Associate Professor of Civil Engineering, University of Illinois *(for many years in Research Lab., A.R.A.)*

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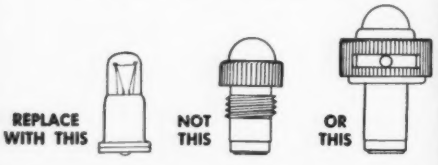

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Continued from page 1259

Technical Operating Personnel

This category includes operating supervisors, technical assistants, and technologists. They are the ones who make many of the final decisions as to whether existing instruments are satisfactory and what types of instruments will be used in new plants. They are usually the ones through whom the Instrument Engineer accomplishes much of his work. He must win their favor for any changes or experiments he wishes to try. He depends on them to recognize and report problems which he can work out for them. Whether his job is one of real accomplishment and progress or just instrument fixer depends on their good-will and cooperation. If their knowledge of instrumentation is fairly extensive, they can relieve him of much of his burden.

Therefore, systematic instruction of these men would be ideal. However, the demands of their jobs are such that a practical compromise is to give them an understanding of the potentialities and limitations of instruments. To gain this end they must know how instruments work—that is, how the proportional band, reset, and derivative functions operate, what cascaded systems are and where they should be used, what points are important about orifice meters and rotameters, and similar subjects.

Not to be overlooked, of course, is the relationship between instruments and processes. Although the final decisions in choosing instruments may be made by the Instrument Engineer, he has a hard time getting his recommendations accepted when the technical and operating personnel have different ideas. Therefore, the technical and operating men should understand why a simple proportional-band controller is usually insufficient, and why derivative control, boosters, and valve positioners are needed.

The best way to give them this information is to organize about ten men in a discussion group led by an Instrument Engineer, the group holding a two-hour meeting once a month. It will be found that such a series of meetings can extend over one or two years. In the early meetings basic subjects can be covered, but men in this category will cover the ground rapidly because of their previous training and experience. Subjects for future meetings soon crop up in the form of questions about specific plant problems. In the later stages the meetings will be discussions of actual plant problems for which the Instrument Engineers have not had ready answers. New standards, specifications, and policies are formulated by the group. The group takes on the appearance of a working Instrumentation Committee. In this form it becomes of great value to the Instrument Engineers and, of course, to the plant as a whole.

Plant Operators

Perhaps the greatest controversy is over how much training to give plant operators. Ideally, an operator should be an accomplished Instrument Man, just as ex-operators generally make the best Instrument Men. As this ideal is seldom reached, it is not a practical matter for consideration. On the contrary, sad experience has proven that a number of operators are at that low level of knowledge where their ignorance is not apparent to themselves and they think they know it all. They are a nuisance to the Instrument Men by unintentionally sabotaging the instruments, also causing themselves unnecessary troubles. If we try to solve this problem by withholding practically all knowledge from them, we hinder the intelligent use of instruments. To raise them all safely above the nuisance level of knowledge is a large task and would consume too much time. Owing to the different mental capacities of different individuals, it seems that any practical amount of operator training will leave some operators with insufficient knowledge, some at the nuisance level, and some well trained.

This problem must be solved from a different approach. Draw a line between the parts of an instrument which the operator may handle and those which the Instrument Man may handle. As the operator runs his process to a great extent by adjusting the temperatures, pressures, flow rates,

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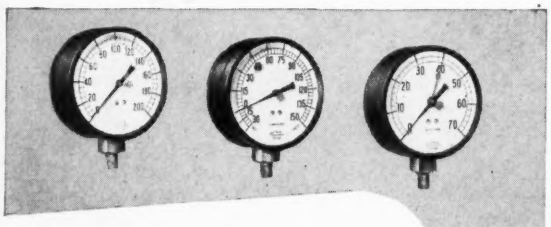

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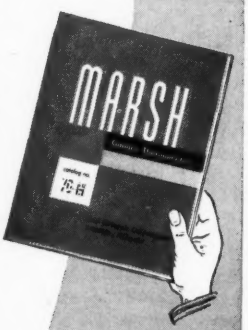

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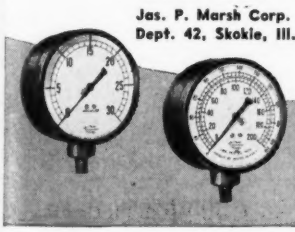

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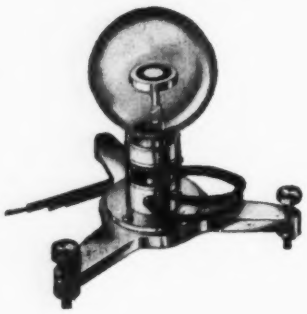

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levels, and so on, he must be the one who moves the index pointers of the instruments. On the other hand, the Instrument Man should be the one to handle the proportional band, reset, derivative, synchronizing, and calibrating adjustments. When, in the course of his duties, the Instrument Man must make slight changes in the index setting, he should do it in cooperation with and under the supervision of the operator.

This line of thought leads to the point which should have the greatest emphasis in operator training, namely, that the adjustment of the instruments is a cooperative function between the operator and his Instrument Man. The only way to accomplish it is in strict harmony.

Formal training of operators should be in scheduled classes. The training should be given to men who have spent time on the units, at least as helpers, in order that they will have a sufficient understanding of what is being taught. Almost necessarily, these sessions will be held during shutdowns or turn-arounds when a group of operators can leave the units for hours at a time.

The instructor should be either an Instrument Engineer with a good understanding of operations and operators, or a respected operator with an unusually good knowledge of instruments. Too often a group of operators develop strange ideas and prejudices about instruments. An operator trying to train his fellow operators in instrumentation is often like the blind leading the blind. He fails to dispel the illusions. Likewise, the Instrument Engineer who does not understand the operator's viewpoint will probably explain proportional band and reset in terms of bellows and needle valves, and stop there. The operator fails to connect these ideas with his experiences while reading recorder charts. To him in his work, these items are seen in terms of recorder charts and output air gages. The operation of the instrument should be explained to him in terms of the charts, air-gage pressures, and other factors with which he is familiar.

Common fallacies must be studiously combated. For example, if a proportional band is set wide enough to insure stability, the operator often fears that the instrument will lose control during an upset. He will prefer a small cycle to assure him that the instrument is working. Another "old wives' tale" is that the purpose of reset is to "slow down the instrument" so that it will not overshoot during an upset. Derivative gives rise to little short of hysterics because it causes the output air to change so fast. Only by teaching and demonstrating the real action of controllers can these fallacies be overcome and the prestige and usefulness of instruments be established.

There are other subjects which operators should understand. Cascaded controllers are useful in certain applications, but are baffling to the uninformed operator. When he understands them, he won't try to change the control point of the master instrument by manually moving the index of the slave instrument, or try to slow down the response of the master by lengthening the reset time of the slave. He should learn that instruments are not infallible and are not to be condemned categorically because they occasionally need adjustment and repair. Likewise, he should learn that dampening the response of an instrument by pinching down a valve in its measuring line may easily stop its response altogether; and opening the bypass around a control valve hampers the action of a controller rather than sharpening it by making it a vernier or trimmer.

Great progress can be made by using the miniature process in the classroom. The effects of a too-narrow proportional band and a too-fast reset can be seen, whereas in the plant such upsets must be avoided at all costs and cannot be studied.

A class of operators is a pleasure to teach. It will be found that in spite of their familiarity with instruments, their knowledge is small. Their interest and curiosity grow rapidly with learning, and it is difficult to bring the class work of a group of old operators to a close.

Wide variations from the plans outlined will be dictated by circumstances. However, one underlying theme is evident—if a plant is to benefit from the rapidly advancing use of instruments, sound thinking and planning must be utilized and ample time and facilities must be provided for training.

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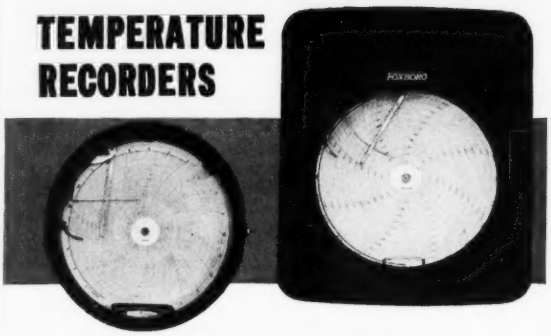

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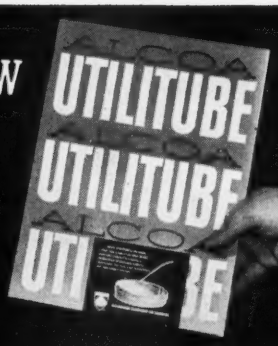

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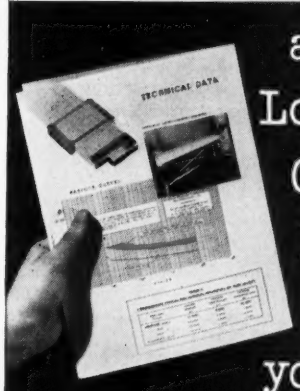

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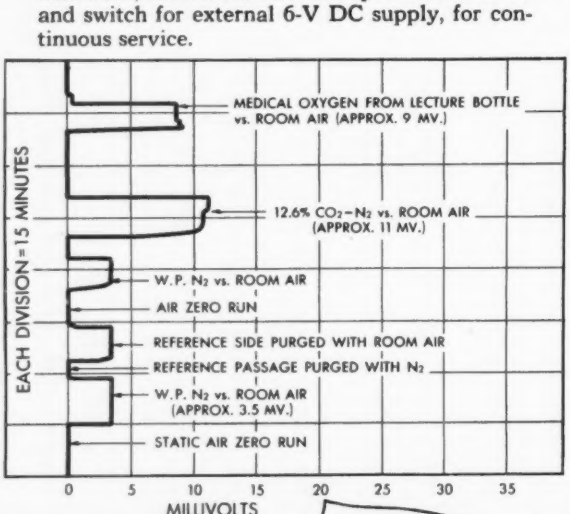
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INSTRUMENT ELECTRONICS

Continued from page 1265

Protection. In addition to high input-impedance, high sensitivity, and usefulness to high frequencies, the VTVM has the advantage that accidental application of an overload voltage can not burn out the indicating meter. The maximum current through the p-m. m-c. indicator is limited by the plate currents in the tubes, which is not large enough to burn the meter out. Further, a rugged meter element that is not susceptible to mechanical injury or burning out can be used because the vacuum tube amplifies the power of the input signal.

Typical VTVM. Fig. 12-6 shows the circuit, including a-c. probe, of the "Model 62" VTVM of Measurements Corporation. The instrument has five a-c. and d-c. ranges from 0-1 volt full scale to 0-100 volts full scale. The accuracy on both d-c. and a-c. ranges is plus or minus 2 percent. The input resistance for d-c. measurements is in the order of hundreds of megohms, limited only by the grid current of the type-6C5 tube. For a-c. measurements the input impedance is 5 megohms shunted by 7 uuf. The frequency range for a-c. measurements is 60 cps. to 150 Mc.

Signal Generators

Signal generators are oscillators that produce signals for testing, adjusting, or calibrating electronic circuits.

There are two basic types of signal generators—frequency standards and test oscillators. The former provides a relatively weak signal of high frequency-stability and low harmonic-content; the latter provides a stronger signal of less stability. The signals usually are adjustable both in frequency and amplitude for maximum utility; ranges of adjustment of both frequency and amplitude are important characteristics of signal generators. High-quality generators do not change signal amplitude with frequency change, and vice-versa.

Circuits

Most of the oscillators described in Chapter 10 are used in commercially available generators. Phase-shift, Wien-bridge, and beat-frequency oscillators are used as test oscillators at low frequencies (from a fraction of a cycle to ultrasonic frequencies); tuning-fork oscillators are used as audio-frequency secondary standards. Electron-coupled, dynatron, and transitron oscillators are used from very low to high radio frequencies; crystal-controlled and electron-coupled oscillators are used as secondary frequency standards at these frequencies. The ultraudion, Klystron, and magnetron oscillators are used at radio frequencies in the VHF, UHF, and SHF bands (see table VIII for the decade classification of radio waves). The Klystron is the more stable continuous-wave (c-w.) oscillator and is used most often at UHF and SHF frequencies.

Table VIII.—DECADE CLASSIFICATION OF RADIO WAVES

Frequency, kc.	*Wavelength, meters*	*Designation*
10 to 30	30,000 to 10,000	Very low frequency (VLF)
30 to 300	10,000 to 1,000	Low frequency (LF)
300 to 3000	1,000 to 100	Medium frequency (MF)
3000 to 30,000	100 to 10	High frequency (HF)
30,000 to 200,000	10 to 1.0	Very high frequency (VHF)
300,000 to 3,000,000	1.0 to 0.1	Ultrahigh frequency (UHF)
3,000,000 to 30,000,000	0.1 to 0.01	Super high frequency (SHF)

Features of Test Oscillators

The test oscillator delivers a signal either pure, tone modulated, or frequency modulated for testing and adjusting electronic circuits. Accuracy of output frequency is not as important as is adequate and adjustable signal strength (amplitude). This is because the test signal may be applied to either high-gain or low-gain circuits; the former require only small signals, the latter require large signals. In operation it is important that the output test signal remain constant when the signal is coupled into various parts of a circuit for test or analysis. Many test oscillators have

an output meter so that the output can be measured and maintained constant by manual adjustment.

Most test oscillators provide outputs at various impedances—the most common being 50, 72, 300, 500, and 600 ohms. This is done to provide maximum power transfer to the circuit under test, to minimize reflections and standing waves, and to make comparisons of voltage measurements at different impedances.

Secondary standards and high-stability test oscillators use regulated power supplies. Line-voltage regulation also should be used when portable a-c. generators or fluctuating line-voltages are used. It is important to remember that oscillators do not reach maximum stability until they are in operation for a time sufficient for the circuit to reach a stable temperature.

WWV Standard-frequency Transmissions

Station WWV, the National Bureau of Standards, transmits standard radio frequencies that are useful for checking frequencies and testing circuits and other oscillators. The schedule of WWV transmissions is shown in Table IX.

Each carrier frequency and each audio frequency is accurate to better than 1 part in 50,000,000. Each interval of 1 second is accurate to 1 microsecond. Station letters WWV and voice announcements are given 1 minute before the hour and half hour.

Table IX.—SCHEDULE OF WWV SERVICES

Carrier Frequency, Mc.	*Time of Broadcast*	*Power Output, kw.*	*Modulating frequencies, cps.*
2.5	Continuously	0.7	1 and 440
5.0	ditto	8.0	ditto
10.0	ditto	9.0	1,440 and 4000
15.0	ditto	9.0	ditto
20.0	ditto	8.5*	ditto
25.0	ditto	0.1	ditto
30.0	ditto	0.1	1 and 440
35.0	ditto	0.1	1

* 0.1 kw. for first 4 work days after 1st Sunday of each month.

Oscilloscope

The oscilloscope is an instrument that uses a cathode-ray tube for making signals visible. It has great utility as a servicing tool because no other instrument permits visual observation of the shape and waveform of the signal in a circuit. The principles of the cathode-ray-tube oscilloscope are used also in television and radar.

The cathode-ray tube (Fig. 12-7) has an electron gun that produces a beam of electrons. The beam is focused so that it strikes a fluorescent screen at a point. The point of impact is visible because light is emitted when the beam of electrons strikes the fluorescent material.

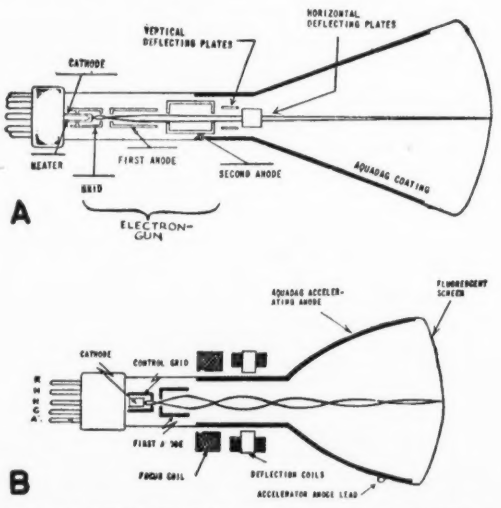

Fig. 12-7. Cathode-ray tubes. A, electrostatic; B, magnetic.

The oscilloscope makes it possible to "see" rapidly changing electrical voltages because the electron is the lightest known mass and yet is endowed with a charge. Owing to

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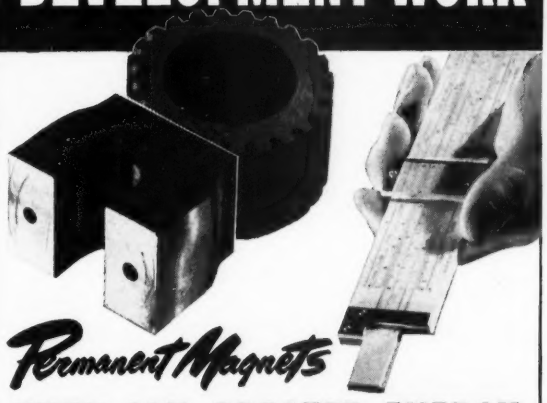

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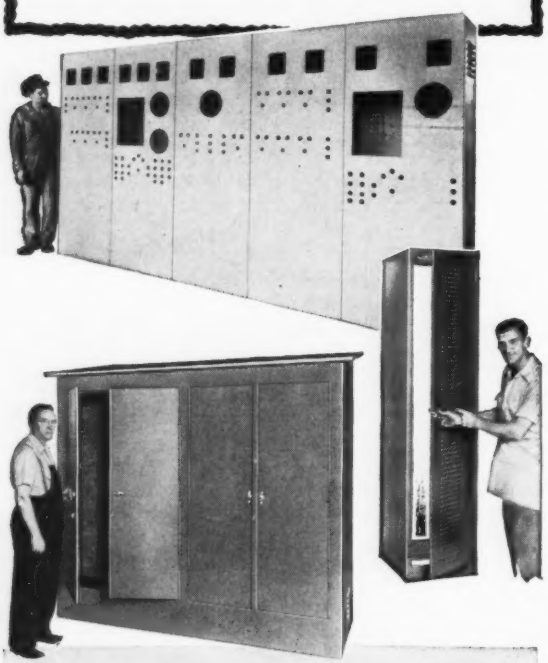

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its infinitesimal mass, it has negligible inertia and can be started, moved, and stopped with negligible delays (in the order of thousandths of a microsecond). The charge on the electron makes it possible to accelerate and decelerate the electron by bringing a voltage (an electric field) near the electron. This is done in the cathode-ray oscilloscope by applying the signal to be observed to the vertical-deflection plates (through an amplifier). Variations in voltage of this signal cause the spot to move vertically in instantaneous response to the signal variations. At the same time, the spot is swept horizontally across the screen (from left to right) by a *sweep signal* applied to the horizontal-deflection plates. The result is a pattern on the screen, showing the waveform of the signal applied to the vertical-deflection plates. Fig. 12-8 shows 4 cycles of an applied sine wave; this pattern is produced when the horizontal sweep frequency is ¼th the frequency of the signal observed.

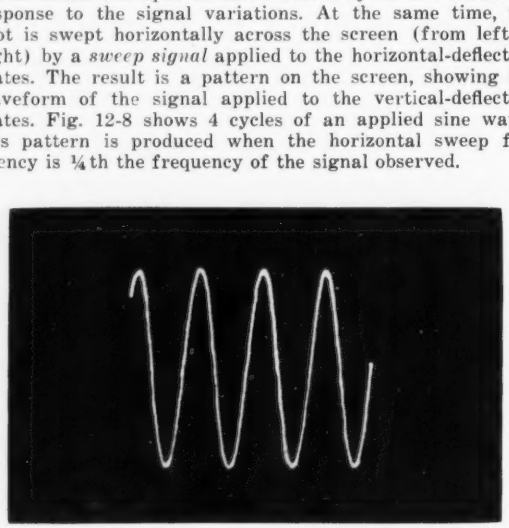


Fig. 12-8. Oscilloscope pattern showing 4 cycles of a sinoidal signal.

Cathode-ray Tubes

Types. There are two types of cathode-ray tubes—electrostatic and magnetic. The electrostatic cathode-ray tube, shown in Fig. 12-7,A, uses electric fields to focus the beam and to deflect the spot both horizontally and vertically. As an electron can be deflected by a magnetic field as well as by an electric field, magnetic fields produced by current in coils around the neck of the tube can perform the same functions as the electrostatic fields produced by the plates inside the electrostatic tube. Fig. 12-7,B shows a cathode-ray tube that uses magnetic fields to focus and deflect the beam. The *focus coil* in the magnetic type produces the field that focuses the beam. Two crossed pairs of coils in the *deflection coil* are used for vertical and horizontal deflection of the spot.

The advantages of magnetic control are (1) tube simplicity, (2) tube ruggedness, (3) shorter tube length, and (4) greater deflection of spot for large-face tubes. Thus magnetic control is used in television receivers and radar indicators that use large-size cathode-ray tubes. The advantages of electrostatic control are (1) a simpler deflection circuit and (2) less power consumption by the deflection circuit. Most oscilloscopes use electrostatic control.

Electron gun. The term "electron gun" refers to the cathode, filament, grid, and first two anodes, which produce the collimated beam. The first and second anodes focus the electrons into a sharp beam. The first anode often is called the *focusing* anode; the second anode often is called the *accelerating* anode. Although both electrodes accelerate and focus the beam, the first-anode potential is varied to adjust the focusing.

The inside of the tube is coated with electrically conducting *aquadag*, which serves as the return path for secondary electrons emitted when the beam strikes the screen. The highest positive potential in the circuit is applied to this coating to help accelerate the electrons to a high velocity so that the spot is brilliant. This lining is referred to as the accelerating lining (because it accelerates the electrons) or as the intensifier lining (because it intensifies the beam). In some oscilloscopes a metal anode, called an *intensifier ring*, is cemented to the inside of the glass and no aquadag coating is required.

Fluorescent screen. The screen consists of chemicals deposited on the inside face of the cathode-ray tube. Tubes are available with materials that fluoresce with green, white, blue, or yellow color; green and white are used most commonly. After the impact of an electron, the glow persists for a fraction of a second. The duration of the afterglow, or *persistence*, is what makes the trace visible. Tubes of various persistence are available.

Positioning. The spot can be positioned anywhere on the face of the cathode-ray tube by (1) changing the d-c. operating potential of the deflecting plates in electrostatic tubes or (2) changing the direct current in the deflection coils of magnetic tubes.

Intensity. The intensity of the beam is controlled, or modulated, by adjusting the grid-cathode bias, which determines the number of electrons in the beam. This intensity modulation of the beam often is referred to as the Z axis of the tube—that is, the spot can be varied horizontally (X-axis), vertically (Y-axis), or in intensity (Z-axis).

Components of Oscilloscope

Fig. 12-9 shows the basic components of an oscilloscope—(1) cathode-ray tube, (2) horizontal-deflection amplifier, (3) vertical-deflection amplifier, (4) sweep generator, and (5) power supply.

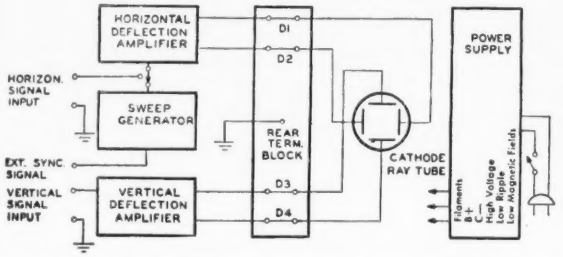


Fig. 12-9. Basic components of a cathode-ray oscilloscope.

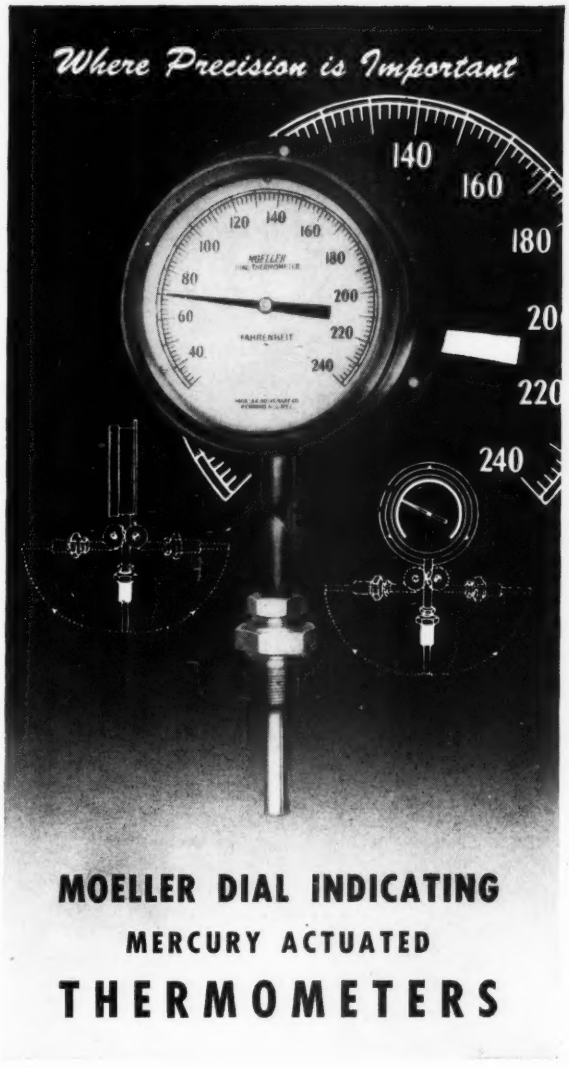
Sweep Circuit. For observing a signal, the spot is swept across the tube from left to right. The spot then is returned rapidly to its starting point; the spot is blanked out during the small interval in which it "retraces" to its starting point. Except for this short retrace interval, all signal variations can be seen on the screen.

The sweep generator provides the signal that sweeps the spot horizontally across the tube. It usually is a relaxation oscillator that produces a linear sawtooth waveform. It is adjustable in frequency of operation, and is provided with means for synchronizing the sweep generator with any external signal. This is called external sync. The sweep generator can be synchronized also with a portion of the signal taken from the vertical-deflection circuit. This *internal synchronization* causes the sweep generator to oscillate at exactly the same frequency (or a submultiple) of the signal to be observed, resulting in a stable, visible pattern.

Deflection amplifiers. The vertical-deflection amplifier amplifies the signal to be observed. It usually is a wide-band R-C-coupled video amplifier with push-pull output for driving the two vertical-deflection plates in opposite polarity.

The horizontal-deflection amplifier amplifies either the signal from the sweep generator (when an internal sweep-signal is used) or any external signal applied to the input posts marked HORIZONTAL INPUT. As it usually receives the large signal from the sweep generator, the horizontal-deflection amplifier does not require as much gain as the vertical-deflection amplifier, which receives unknown signals of all amplitudes. The horizontal-deflection amplifier, like the vertical-deflection amplifier, has push-pull output for driving the two horizontal-deflection plates in opposite polarities.

As the horizontal- and vertical-deflection amplifiers of most oscilloscopes are R-C coupled, they cannot handle d-c. signals. Therefore, the deflection plates usually are connected to external posts so that d-c. signals can be ob-



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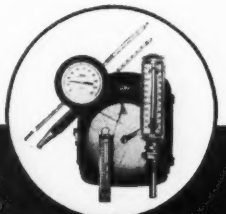

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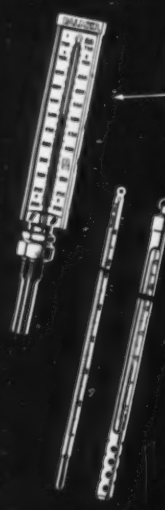

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served by applying them directly to the posts (Fig. 12-9). As no amplification precedes signals applied directly to these posts, only signals of relatively large amplitude (volts) can be observed in this manner. In other words, the *deflection sensitivity* of the deflection plates is several volts per inch deflection. Some oscilloscopes provide for d-c. amplification.

Power Supplies. The power supply must supply conventional plate and screen potentials of several hundred volts, and a high potential for the accelerating and intensifier (aquadag) anodes. In conventional oscilloscopes the accelerating potential is about 1500 volts; the intensifier voltage is about 3000 volts.

Typical Oscilloscope Characteristics

The following characteristics of the DuMont "Type 304-H" oscilloscope emphasize the important features and responses of a typical test oscilloscope:

X and Y amplifiers. Response down less than 10 percent at 100,000 cps; less than 50 percent to 300,000 cps. This means that both X and Y amplifiers are useful for observing waveforms with frequency above 300,000 cps.

Vertical deflection factor. Through vertical amplifier at full gain: 0.01-rms. volt input signal causes 1-inch vertical deflection of spot. When signal is applied direct to plates: 18-rms. volts produce 1-inch vertical deflection.

Horizontal deflection factor. Through X-axis amplifier: 0.05-rms. volt per inch. Direct to plates: 21-rms. volts per inch.

Sweeps. Recurrent and driven linear sweeps variable in frequency from 2 to 30,000 cps. Provisions for extra-low-frequency sweeps. Return trace automatically blanked. Sweep may be synchronized by signal of either polarity. All sweeps can be expanded to six times screen diameter for study of high-frequency components of low-frequency signals.

Intensity modulation. External negative signal of 15 volts (peak) will blank beam at normal intensity settings.

Uses

The oscilloscope has five basic uses—(1) observation of waveform, (2) measurement of frequency, (3) measurement of phase, (4) measurement of voltage, and (5) measurement of time. The primary use is observation of waveform. Signals can be traced through a circuit and sources of distortion can be found merely by observing the signal at various points in a circuit.

Another important use is the determination of the *frequency* of an unknown signal by comparison with a known signal. For this application no sweep signal is used. The known signal is applied to one set of deflection plates and the unknown is applied to the other set. Fig. 12-10 shows patterns for various ratios of frequencies. Note that the ratio of frequencies is found from the number of times that the waveform reaches a maximum in horizontal and vertical directions.

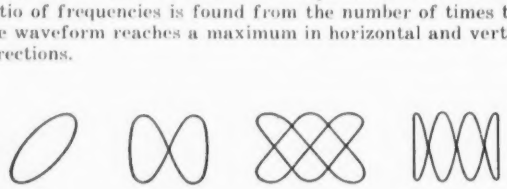
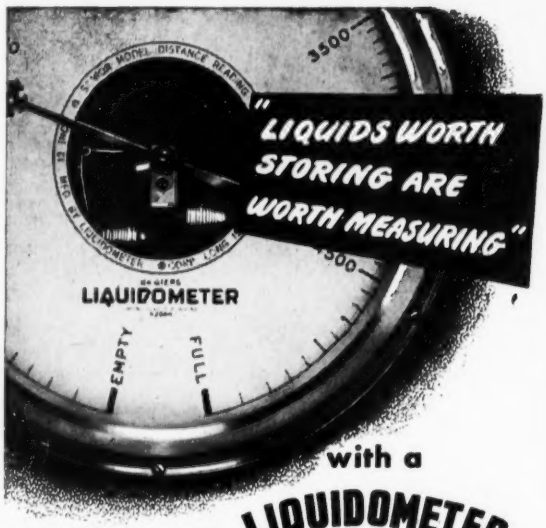


Fig. 12-10. Patterns produced when two signals of different frequencies are applied to the deflection systems, and no internal sweep is used. A, ratio of frequencies is 1:1; B, ratio is 2:1; C, ratio is 3:2; D, ratio is 4:1.

When two waves of the same amplitude and frequency are applied to the deflection plates, variations in *phase* between the waves produce the patterns shown in Fig. 12-11. The phase relation of the signals is observable from the pattern.

The oscilloscope can be used as a *voltmeter* for d-c. or a-c. signals by calibrating the deflection-plate sensitivity or de-



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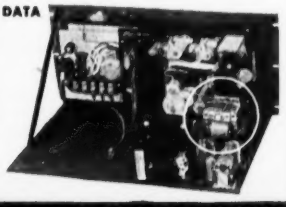

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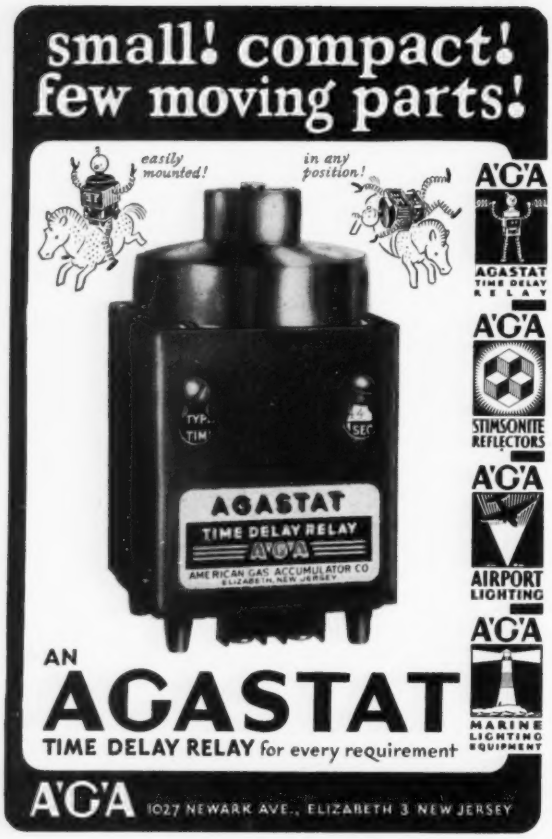

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flection amplifiers. However, it is not used generally for this purpose because commercial voltmeters have greater accuracy, range, and stability.

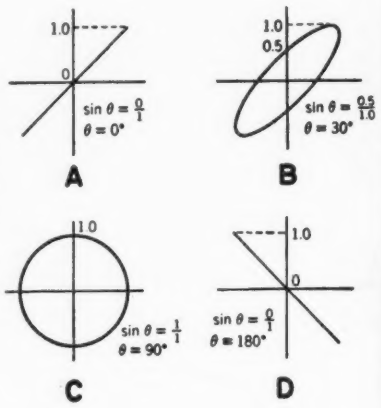

Fig. 12-11. Patterns when signals of same frequency but different phase are applied to deflection systems, and no sweep is used. A, phase between signals is 0 deg.; B, phase is 45 deg.; C, phase is 90 deg.; D, phase is 180 deg.

As the sweep is a linear time base, the duration of signals and the duration between signals can be measured. This time-measurement function is the heart of the radar, in which the time for a pulse to travel from radar transmitter to target and for the echo to return to the radar receiver is indicated in terms of a displacement of a signal on the face of a cathode-ray tube.

Synchroscope

An oscilloscope with a single sweep that is generated only when a synchronizing signal is provided is called a synchroscope. Synchroscopes are useful for observing short pulses which may or may not be repetitive. The pulse to be observed is fed to the vertical-deflection plates through a delay device that delays it for a period of microseconds. During the delay period, the pulse triggers the sweep, so that the spot is near the center of the tube before the deflection occurs. Note that the DuMont "Type 304-H" described previously has a driven, as well recurrent, sweep available. Hence this test oscilloscope can be called a "synchroscope."

Tube Testers

Vacuum tubes can fail for many reasons—coated cathodes lose emission because the cathode coating flakes off; impregnated emitters of filament-type tubes become exhausted with age; air can leak into the tube through defective seals and "poison" the emitting surface; vibration can cause shorts or opens. Commercial tube testers usually provide means for testing for emission, quality, shorts, noise, and gas.

There are several types of tube testers—the two most common being the *emission type* and the *mutual-conductance* type. The former, which is the more economical, usually connects all grids, screens, and plates together and checks for electron emission only. The latter applies an a-c. signal to the grid of the tube and tests the signal output of the tube.

The RTMA (Radio and Television Manufacturers Association) proposes to classify tube testers into four classes as follows (Fig. 12-12):

Class I—*Emission-type tester*, a device incorporating a circuit in which the indication is related primarily to the emission of the tube being tested.

Class II—*Control-emission type tester*, a device incorporating a circuit in which the indication is related jointly to the emission and to the control characteristics of the tube being tested.

Class III—*Control-type tester*, a device incorporating a circuit in which the indication is related primarily to the control characteristics of the tube being tested.

Class IV—*Mutual-conductance-type tester*, an instrument incorporating a circuit which permits quantitative measurement of g_m.

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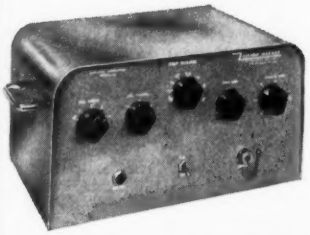

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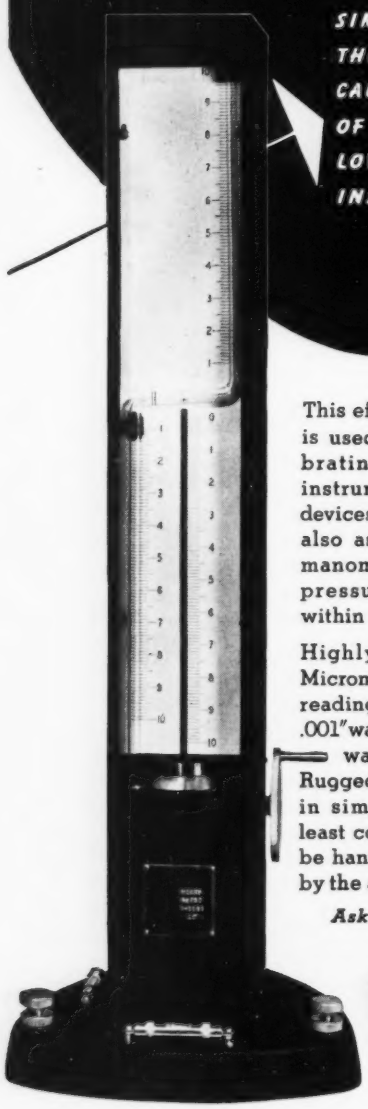

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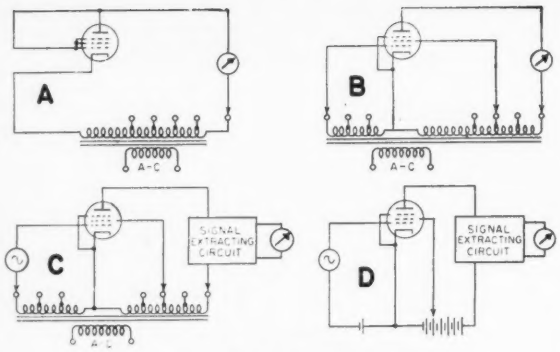

Fig. 12-12. Proposed classifications of tube testers.

but with a grid signal. The control type analyzes the signal output, rather than measuring plate current only. The conductance type uses d-c. operating potentials and signal measurements so that the dynamic mutual conductance of the tube ($\Delta I_p/\Delta E_g$) can be measured.

Instrument Transformers

The ranges of a-c. voltmeters and ammeters can be changed either by using series resistors, parallel (shunt) resistors, or instrument transformers. The latter are used when series and parallel resistors become too bulky and inefficient, as often occurs with movable-iron and electrodynamic movements.

A *potential transformer* for changing the voltage of an a-c. signal, is a conventional transformer with a step-down turns ratio for reducing the voltage. Except for the fact that polarity workings must be observed, there is no danger in using a potential transformer because (1) the voltmeter is a low-current high-resistance device and no heavy currents are developed and (2) the insulation is designed for the voltage step-up or step down. However, special precautions must be observed when using a current transformer.

A *current transformer*, for stepping current down, has the ammeter connected to the secondary (Fig. 12-13). The secondary, or meter side, of the transformer *must* be shorted

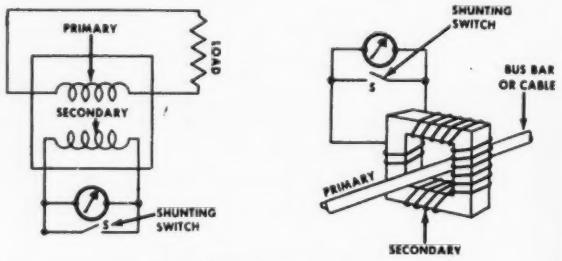

Fig. 12-13. Current-transformer connections.

before the meter is removed because the same turns ratio that reduces current by a factor of 100, increases the voltage by the same factor. Thus if the secondary current is zero, the secondary voltage becomes large enough to puncture the insulation and burn out the transformer.

A potential and a current transformer can be used with an electrodynamic wattmeter to change the range.

Frequency Meters

There are two types of frequency meters, or wavemeters —absorption and heterodyne. The former is simply a resonant tank with a method for indicating the current in the tank. When the resonant circuit is brought near an oscillator, oscillation is induced in the tank if the tank is tuned to the frequency of the oscillator. The current in the tank can be indicated by a neon glow lamp (for high-power measurements) or a rectifier-type p-m. m-c. movement. The advantages of absorption-type wavemeters are (1) sim-

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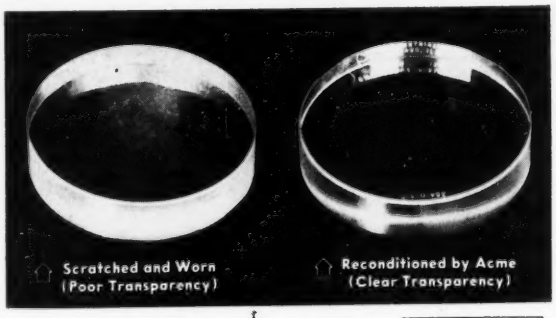

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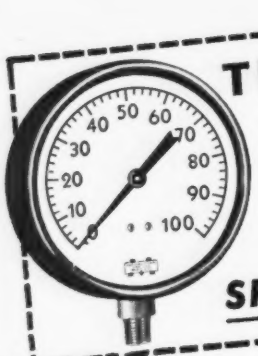

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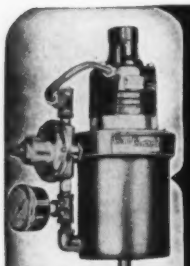

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plicity and (2) they oscillate only at their fundamental frequency; for this reason they are used commonly to check if a transmitter is operating on the correct multiple of its oscillator frequency. The disadvantage of absorption-type wavemeters is that they detune the oscillator when coupled to it. Hence they cannot be used for precise frequency measurements.

Absorption-type wavemeters are available at all radio frequencies. Parallel-resonant tanks are used at low, medium, and high radio frequencies. Butterfly tanks are used in the VHF band. Tuned cavities are used in UHF and SHF bands.

The *heterodyne* type of wavemeter uses an accurately calibrated oscillator to heterodyne against the unknown; a zero beat frequency is produced when the two oscillations are at the same frequency. Precautions must be observed when using heterodyne-type frequency measurements to assure that measurements are not being made with harmonics (rather than the desired fundamental frequency) of the calibrated oscillator. Any secondary frequency standard (including WWV transmissions) can be used in this manner to measure and to adjust the frequency of transmitters and receivers.

Field-Intensity Meters

A field-intensity meter is essentially a portable radio receiver with a method for indicating the strength of a received signal. When used with a directive antenna, such as a loop antenna, they can be used to locate interfering signals, check field patterns, etc. Radio receivers and antennas are described in the next chapter.

TEST ITEMS FOR CHAPTER XII

12-1. The moveable-iron movement differs from the permanent-magnet moving-coil movement in that the former
(a) responds to a.c. or d.c.
(b) uses the field produced by a permanent magnet
(c) is delicate
(d) has one coil through which the current flows

12-2. The electrodynamic movement differs from the permanent-magnet moving-coil movement in that the former
(a) responds to a.c. or d.c.
(b) has two windings through which the current flows
(c) can be used as a wattmeter
(d) has all the above features

12-3. Which of the following movements is used as a transfer standard?
(a) Permanent-magnet moving-coil
(b) Moveable iron
(c) Electrodynamic
(d) All the above

12-4. A p-m. m-c. volt-ohm-milliammeter with an input resistance of 20,000 ohms per volt has a
(a) 20-ua. movement
(b) 50-ua. movement
(c) 100-ua. movement
(d) 1-ma. movement

12-5. The most important advantage of a VTVM over other voltmeters is
(a) higher accuracy
(b) same response to a.c. or d.c.
(c) higher input impedance
(d) all the above

12-6. The response of a VTVM to peak, average, or rms, value becomes an important consideration when measuring
(a) d-c. signals
(b) pure sine waves
(c) nonsinoidal signals
(d) all the above

12-7. The reason for putting the rectifier circuit of a VTVM in the tip of the probe is
(a) to prevent lead-wire capacitance from affecting the d.c. signal
(b) to prevent lead-wire capacitance from affecting the a.c. signal
(c) to prevent high voltages from reaching the user
(d) to make the circuit responsive to peak values of the signal

12-8. Which of the following is preferred for use as a test oscillator for the audio-frequency band?
(a) Tuning-fork oscillator
(b) Phase-shift oscillator
(c) Tuned-plate tuned-grid oscillator
(d) Klystron oscillator

12-9. Which of the following is the most popular circuit for a UHF test-oscillator?
(a) Beat frequency
(b) Tuning fork
(c) Klystron
(d) Magnetron

12-10. A signal with a wavelength of 20 cm. is in which of the following bands?
(a) HF
(b) VHF
(c) UHF
(d) SHF

12-11. The accuracy of the radio and audio signals transmitted by station WWV is 1 part in
(a) 10,000
(b) 500,000
(c) 10,000,000
(d) 50,000,000

12-12. In an oscilloscope, a signal to be observed usually is applied to the
(a) electron gun
(b) sweep circuit
(c) vertical-deflection plates
(d) horizontal-deflection plates

12-13. The sweep signal of an oscilloscope usually is applied to the
(a) electron gun
(b) grid or cathode of the cathode-ray tube
(c) vertical-deflection plates
(d) horizontal-deflection plates

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12-14. Most test oscilloscopes use
(a) electrostatic focus and magnetic deflection
(b) magnetic focus and magnetic deflection
(c) electrostatic focus and electrostatic deflection
(d) magnetic focus and electrostatic deflection

12-15. The advantage of electrostatic deflection over magnetic deflection is that the former has
(a) a simpler cathode-ray tube
(b) a simpler deflection circuit
(c) greater ruggedness
(d) greater spot deflection

12-16. The advantage of magnet deflection over electrostatic deflection is that the former has
(a) a simpler cathode-ray tube
(b) a more rugged cathode-ray tube
(c) greater spot deflection
(d) all the above

12-17. The intensity of the beam of a cathode-ray-tube oscilloscope is controlled by means of
(a) grid-cathode potential
(b) 1st anode potential
(c) 2nd anode potential
(d) intensifier potential

12-18. The "Z axis" of an oscilloscope refers to
(a) horizontal beam motion
(b) vertical beam motion
(c) lateral beam motion
(d) change in beam intensity

12-19. Synchronization in an oscilloscope refers to the synchronization of the
(a) horizontal amplifier
(b) vertical amplifier
(c) sweep oscillator
(d) electron gun

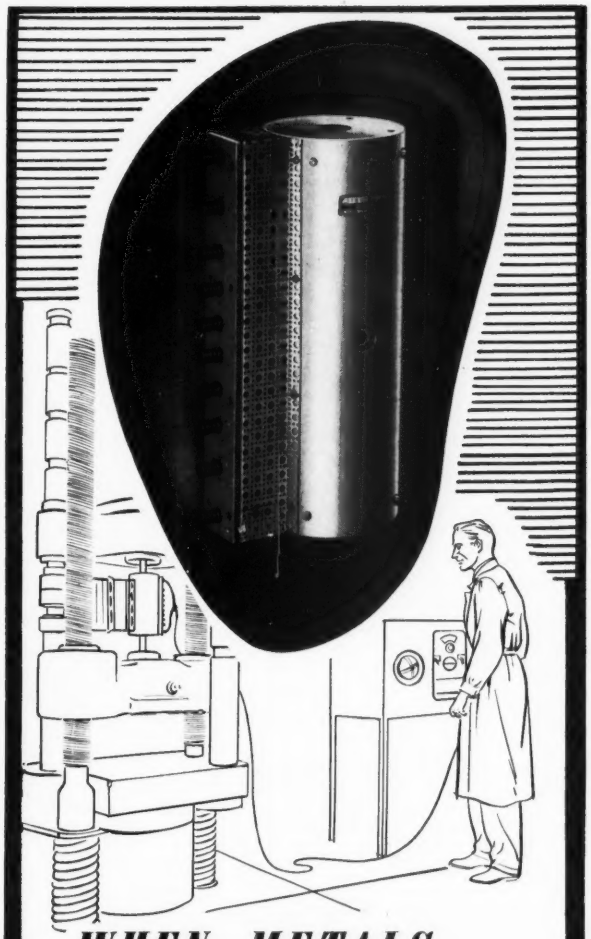
12-20. The deflection plates of many oscilloscopes are connected to external binding posts so that
(a) deflection-plate voltages can be measured
(b) d-c. signals can be observed
(c) a-c. signals can be observed
(d) external amplifiers can be used

12-21. A synchroscope is an oscilloscope with a synchronized
(a) recurrent-sweep circuit
(b) single-sweep circuit
(c) intensity-modulation circuit
(d) phase-measurement circuit

12-22. The basic difference between emission-type and conductance-type tube testers is that the former test tubes
(a) with no grid signal
(b) with d-c. operating potentials
(c) by measuring tube gain
(d) by checking for shorts, noise, and gas

12-23. When using a current transformer to change the range of an a-c. ammeter, which of the following precautions are necessary?
(a) The primary (load circuit) must not be shorted at any time.
(b) The primary must not be opened at any time.
(c) The secondary (ammeter circuit) must not be shorted at any time.
(d) The secondary must not be opened at any time.

12-24. The advantage of absorption-type wavemeters over heterodyne types is that the former
(a) is more accurate
(b) uses a calibrated oscillator
(c) responds only to a fundamental frequency
(d) has all the above features



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Continued from page 1262

be based on personal opinions which are the result of (1) individual experience or preference, (2) problems in a particular plant, (3) standardization policies, or other reasons. Whether or not good measurements are obtained depends on how the instruments are used. To obtain good measurements is still an art.

Science of Control

The science of control is new; only in the last 20 to 25 years has there been a systematic attempt to study the principles involved. In February 1946 some "Automatic Control Terms" were published[1]. These terms define automatic controllers and their characteristics as well as processes and process characteristics. The terms define the three distinct classifications of automatic controllers and the variations of each classification plus the multiple actions which are combinations of the basic actions. Others [2,3] have written equations that mathematically define these actions. Such definitions provide a means to classify all automatic controllers or regulators applied to various types of actions, or modes of control.

Thirty years ago a temperature controller might have been defined as an instrument that maintains a constant temperature in a process. Compare this definition to the more recent definition which states that an automatic controller is a mechanism that detects a deviation of the controlled variable and causes a corrective action. In the first definition it is implied that there is no deviation of the controlled temperature. The second definition emphasizes that there must be some slight deviation of the controlled condition before the controller can operate or

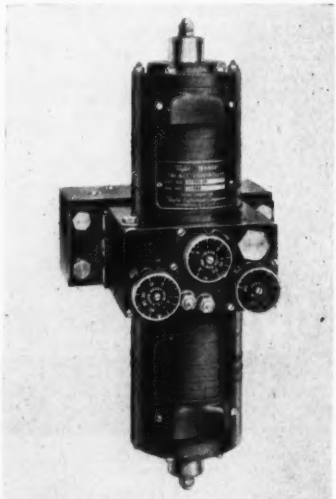

Fig. 3. The science of control. Controller adjustments calibrated in specific units make possible reproducible settings and allow systematic comparisons between different processes.

(1) "Automatic Control Terms" Industrial Instruments and Regulators Division, ASME, *Mechanical Engineering*, February 1946, pages 134-138.
(2) Eckman, D. P., *"Principles of Industrial Process Control"*, John Wiley & Sons, Inc., 1945.
(3) Lauer, Henri; Lesnick, Robert; Matson, Leslie E. *Servomechanism Fundamentals*, McGraw Hill Book Co., Inc., 1947.

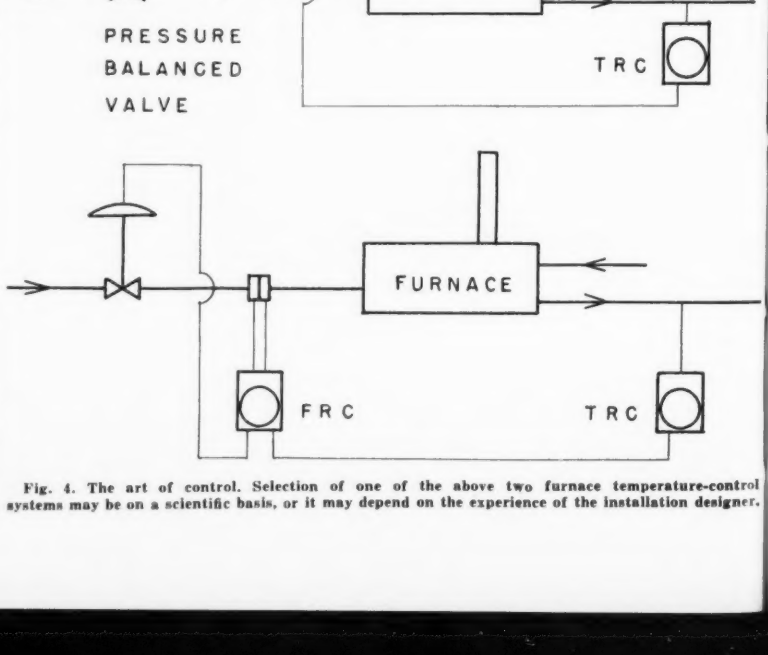

Fig. 4. The art of control. Selection of one of the above two furnace temperature-control systems may be on a scientific basis, or it may depend on the experience of the installation designer.

cause a corrective action. Realizing that a deviation takes place allows controllers to be designed that operate either on the magnitude of deviation or on the rate of deviation (Fig. 3).

As with measuring devices the study of control mechanisms can be scientific. By calibrating the adjustment knobs, settings can be made up of two basic units—the measuring means and the controlling means, each with its own characteristics.

Art of Control

Although an automatic controller is a scientific and predictable mechanism, anyone who has put one into operation will probably challenge the statement. In most installations good control depends on the experience of those designing the installation. As there are many different and new processes to which instruments are applied, it is difficult to accumulate data on which to base laws or principles. Setting a new controller about the same way as another controller was set on a previous job is applying the scientific method, but until some systematic method is developed, the job of setting controllers will remain an art. Some work has been done towards predicting controller settings[4], but when new and different problems are encountered some of the data required may not be available. If tests are made to obtain the data, and if records are kept of the data, a science can be developed; but if it is continually necessary to draw upon unrecorded past experiences, a science will be slow in developing. Use of the fundamentals of instrumentation—physics, chemistry, and mathematics—is the key to the development of a true science of instrumentation.

(4) Ziegler, J. G. and Nichols, N. B., "Optimum Settings for Automatic Controllers," Presented at the annual meeting of I.I.R.D. of A.S.M.E., December 1-4, 1941, New York, N. Y.

DISPLACEMENT METERS

Continued from page 1261

maintaining accurate calibration of transporting and distributing tanks is well known. Frequently meters will point out errors in tank calibration. Also, overloading of such tanks is a human tendency which can add up to large losses. A meter can eliminate this practice.

Most of the transport loadings are inter-company transactions with three interested parties. High accuracy is necessary. To maintain accuracy, there should be a standard against which the meter should be checked regularly. The standard is a calibrated proving tank with a holding capacity not less than one minute's operation of the meter at its maximum rate of flow. Deliveries from a regularly calibrated meter are not likely to be subject to question.

Barrel- and can-filling meters at the refineries or the bulk terminals are applications to which meters are readily and economically adapted. The initial and installation cost is much less than for other accepted methods. The meter installation is more flexible in that it can be moved about as required.

Many refinery operations have corrosive problems that meters can not meet. However, meters are used to advantage in installations such as (1) grease compounding for measuring the oils into the grease-making unit, (2) blending operations, such as asphalt, lube oils, paint thinners, and solvents, and (3) checking inter-department movement of refined and semi-refined products.

At crude-oil gathering stations, meters are used for measuring the oil into the station and from the station storage into the main line. On product lines, meters at the take-off terminals measure products into storage as well as loading transports and trucks. In these services, meters reduce the storage facilities required because it is possible to pump into and out of a tank simultaneously. Meters are used also to handle liquids which contain sand, silt, and water, as in well operation.

Installation, Operation, Maintenance

Satisfactory meter performance starts with the selection of the proper unit for the job. To select a meter it is necessary to know (1) maximum and minimum rates of flow, (2) working pressure, and (3) physical characteristics of the liquid to be metered. Remember that it is more economical to have an over-sized meter than one too small for the job.

We must next inquire whether the installation requires accessories such as vapor separators, strainers, valves, etc. Positive-displacement meters will measure the air or vapor contained in a liquid, as well as the liquid itself. If the liquid to be measured contains air or vapor, an air or vapor separator and eliminator are necessary if accurate measurement is to be obtained.

A metered installation should include a *strainer*, if for no other reason than to protect it against accidents such as the entry of a bolt, nut, or wrench.

Frequently it is desirable and necessary to employ a meter in an installation whose capacity is several times the maximum rating of the meter. A "rate of flow" control valve should be used to protect the meter against damage from excessive speeds.

In planning the installation and operating procedure, make provision for checking or testing the accuracy of the meter periodically. A calibrated proving tank may be justified if exacting accuracy is required. Comparing the meter reading with the careful gaging of a stock or processing tank may be satisfactory if the meter is used only as a check instrument.

The A.P.I. in cooperation with the A.S.M.E. has written a code covering the installation, proving, and operation of positive-displacement meters. The tentative code was A.P.I. No. 1101. A final revised code should be available in the future.

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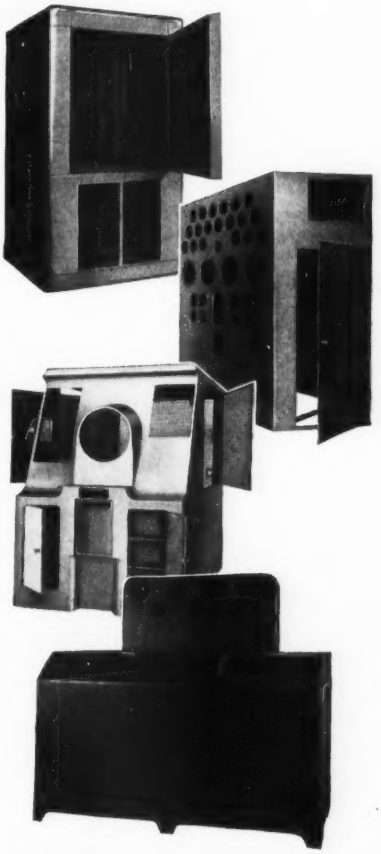

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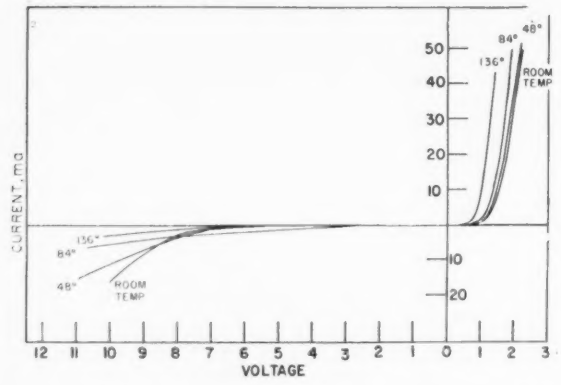
Titanium Dioxide Rectifiers

WASHINGTON, D. C.—A new type of rectifier recently developed by the National Bureau of Standards promises to be the first major improvement in metal-oxide rectifiers since their introduction in 1926. The new rectifier is composed of a layer of semiconducting titanium dioxide, a sheet of titanium metal, and a counterelectrode of some other conducting metal. Preliminary investigations have shown that the units withstand voltage in the reverse direction

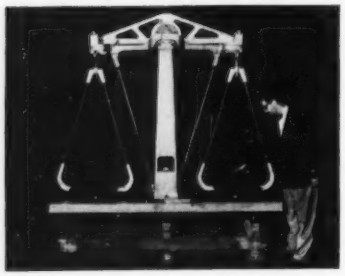


reasonably well and that their properties are satisfactory at elevated temperatures.

The characteristic performance curve shows that the rectifier has improved characteristics at temperatures around 150 deg. C. It is also able to withstand a voltage in the reverse direction of about 20 volts per plate.The rectifier, for which these data were taken, had the oxide layer formed by being heated in steam at 600 deg. C. for 3 hours and 20 minutes. The contact area is 0.08 square centimeter, and a silver plate is used as the counterelectrode.

Large Balance

NEW ROCHELLE, N. Y.—One of the largest balances ever built has just been completed by Voland and Sons, New Rochelle, New York. This huge instrument, one of a very few of this size and sensitivity in the world, has an over-all weight of 3500 pounds. With a total capacity of 200 kilograms in each pan, it maintains a sensitivity of better than 100 milligrams. A tiny piece of metal, 35/10,000 of an ounce, will move this gigantic mechanism when it is loaded to full capacity of 400 pounds. Although the pans are large enough to comfortably seat a grown man, it is impossible to weigh the man because the needle cannot be kept at zero long enough—the balance is so sensitive it records human evaporation while it is going on.



VHF Transistor

NEW YORK, N. Y.—A significant advance in transistor research has been reported by the Radio Corporation of America. Several developmental point-contact transistors were made to oscillate at frequencies well up in the 100-to-200 megacycle band, and one reached a record high frequency of 225 Mc. The highest frequency previously achieved by transistors, according to published reports, has been 50 Mc. Tests have established that a transistor's frequency response and stability are determined to a large degree by the resistivity of its germanium crystal, and by the spacing of the contacts.

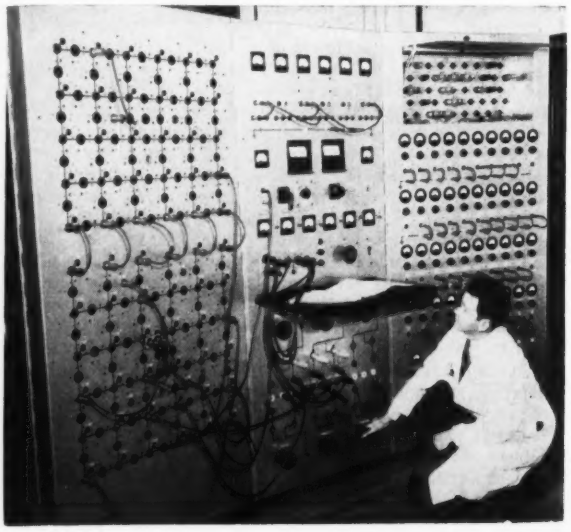
Instrument Maintenance Course

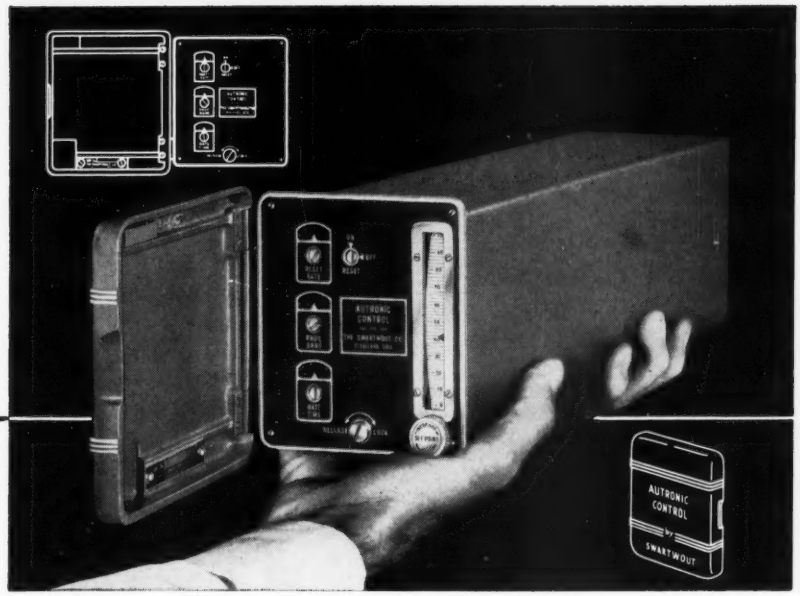
Announcement is made that the Los Angeles Harbor Junior College, Applied Technology Division, and the Southern California Meter Association are to present the Second Annual Instrument Maintenance Short Course at Harbor Junior College November 20-21-22, 1952.

Pipeline-network Analyzer

KANSAS CITY, MO.—A pipeline network analyzer, used in solution of problems involving pipeline flows and pressure losses in pipeline networks, has been installed by Midwest Research Institute. The McIlroy Pipeline-Network Analyzer is one of three such devices in the United States. The others are located at Washington State College and Cornell University, where the first one was installed in 1949.

The analyzer utilizes electrical analogies for physical factors involved in networks carrying water, oil and natural gas, as well as steam-heating networks and air-conditioning systems. An electrical control board is used to duplicate





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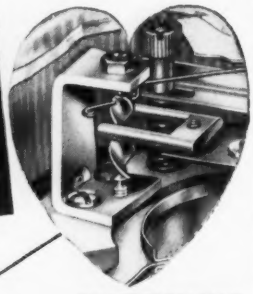

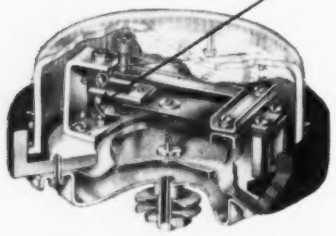

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an actual supply network, which can be composed of as many as 99 different supply lines. The operator can also control such factors as source, rate of flow, pressure and other related elements.

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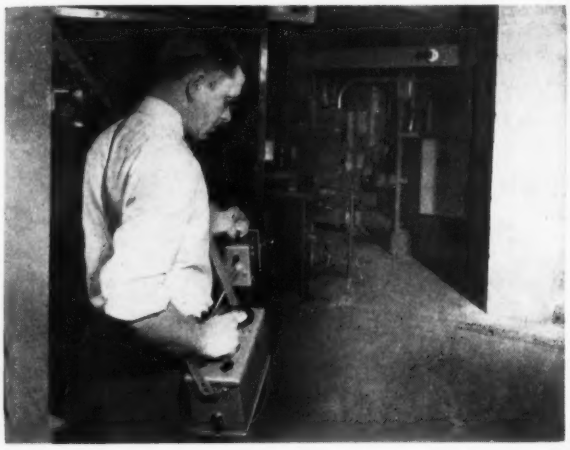
Fast-neutron Dosimeter

DETROIT, Mich.—The problem of fast-neutron radiation exists around cyclotrons, linear accelerators, and nearly all recently constructed reactors. Fast-neutron damage is 10 times that of gamma rays. It has, until recently, been difficult to measure fast-neutron doses in the presence of



other radiation such as gammas. However, the problem is now solved by the "Fast Neutron Dosimeter" developed at Oak Ridge National Laboratory and available from Radioactive Products, Inc., Detroit 26, Mich. The illustration shows the "Raychronix E-1 Fast Neutron Dosimeter" in use within a cyclotron room.

British Exhibition

IMPERIAL INSTITUTE, London.—Shown is a corner of the British Physical Society's recent exhibition at the Imperial Institute, London. An immense variety of scientific equipment was on show, although a condition of exhibiting is that no item can be shown more than once unless further development has taken place in it.

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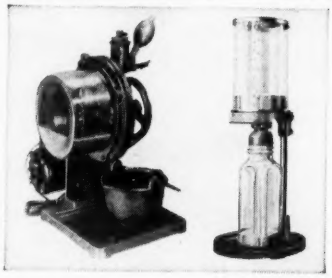

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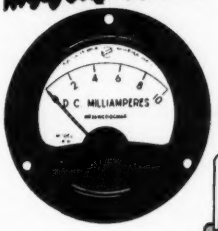

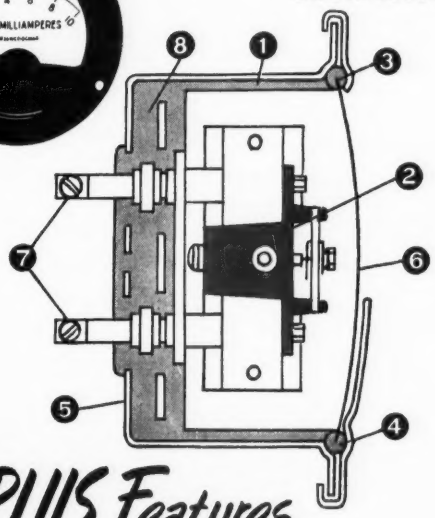

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❼ Terminals side-tapped and provided with tinned binding screws to facilitate wiring with or without wire lugs or by pressure, soldering or both.

❽ Breakage or damage in wiring is reduced through non-rigid mounting of terminals and use of flexible interior conductors.

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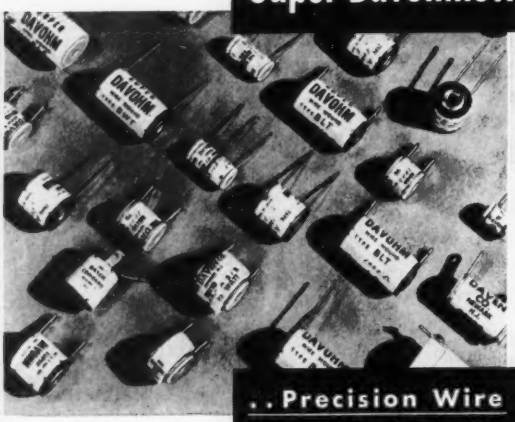

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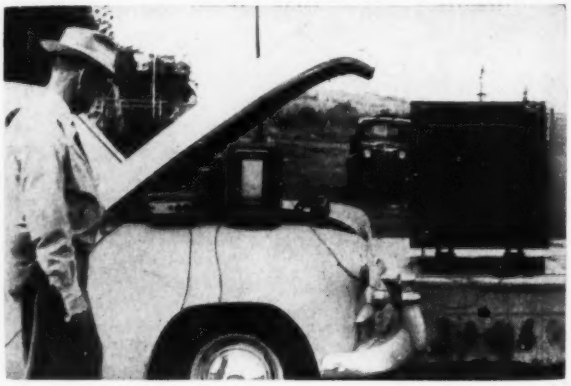
Pipeline Corrosion

EAST BAY, Calif.—Locating corrosion in water pipelines of the East Bay Municipal Utility District in California has been simplified through the use of a General



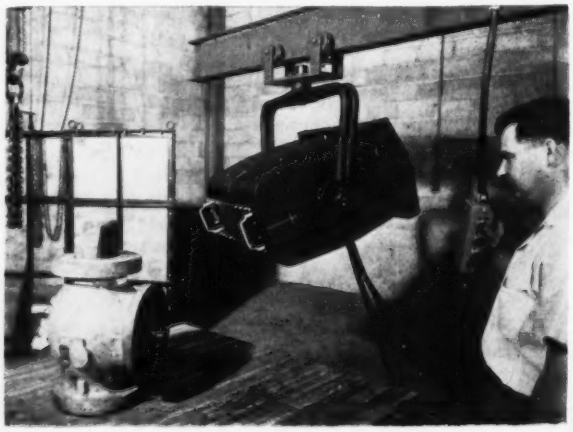
Electric photoelectric recorder. Engineers of the District recently used the instrument to make electrolysis surveys of a 94-mile stretch of water pipe. They set the recorder in their automobiles as they made the tests.

Diffraction School

The fall session of the semi-annual X-ray Diffraction School will be held at the plant of North American Philips Company, Inc., 750 South Fulton Avenue, Mount Vernon, N. Y. during the week beginning Monday, October 6 and extending through Friday, October 10. Registration for the school will be limited.

Radiographic Inspection

Schutte and Koerting Co., of Cornwells Heights, Bucks County, Penna., uses radiographic inspection of steel equipment for high-pressure high-temperature applications. The equipment employed to photograph castings includes a 250,000-volt X-ray machine and a capsule of Cobalt 60, a metal made radioactive by exposure to the atomic pile at Oak Ridge, Tennessee. Both the X-ray machine and the Cobalt 60 produce the required short-wave rays. X-ray-machine rays are used to penetrate castings up to three inches, while Cobalt-60 rays, which have power equivalent to slightly over one-million volts, are used to penetrate castings up to seven inches.



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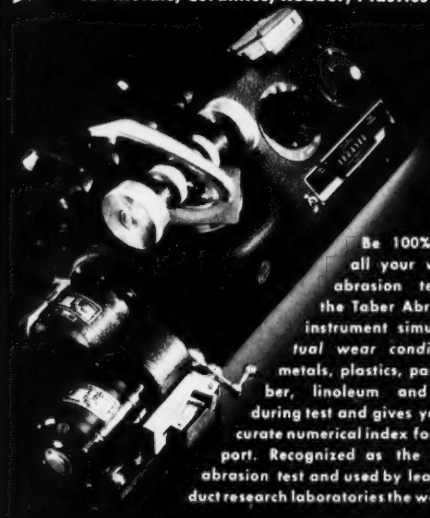

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Manufacturers' New Literature

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Requests for literature FROM ABROAD should be made on company letterhead and mailed DIRECTLY to the manufacturers.

Industrial Process Control

U-860 **Alcohol-vapor Analysis.** 2-page illustrated Instrumentation Date Sheet 10.16-17 describes system for indicating alcohol losses in slops by use of "Atkins Analyzer" and "Electronik" indicator. Includes principle, operation, and table of dollars loss per season, caused by alcohol vapors.—Minneapolis-Honeywell Regulator Co. Brown Instruments Div., Phila. 44, Penna.

U-861 **Industrial Process Control.** 40-page Second Quarter 1952 issue of "Instrumentation" includes technological articles on program control, time-proportioning control, and graphic panels; also descriptions of ways in which various companies apply instrumentation to important process variables.—Industrial Div., Sta. 213, Minneapolis-Honeywell Regulator Co., Phila. 44, Penna.

U-862 **Meat-products Temperature Control.** Folder with loose-leaf contents describes "Cook Meater" automatic temperature controller for smoking meats, curing wieners, etc.—Swieco, Inc., 1513 E. Lancaster, Fort Worth 3, Texas.

U-863 **Smoke Sampler and Recorder.** 6-page mimeographed extracts from Proceedings of Air Pollution & Smoke Prevention Association describe the American Iron & Steel Institute's "Automatic Smoke Filter" developed at Mellon Institute, which aspirates sample through filter-paper fed from a spool and shifted automatically two to five times per hour.—Research Appliance Co., Box 413 West View Road, Pittsburgh 9, Penna.

U-864 **Turbidity Recorder.** 2-page Bulletin 604 describes "TR-6" photoelectric turbidity recorder for continuous monitoring in process-control work; also illustrates various sampling chambers.—Ess Intrument Co., Bergenfield, N. J.

U-865 **Moisture Measurement.** 4-page reprint of *Instruments* article "Moisture Measurement" covers ranges, accuracy, speeds, simplicity, and price of various instrumental methods of moisture measurement. — American Instrument Co., Inc., 8010 Georgia Ave., Silver Spring, Md.

Pressure

U-866 **Small-volume High-pressure Regulators.** 16-page illustrated Bulletin 125-C describes maker's line of self-contained regulators for small-volume flow at high pressures. Includes design and operation features for air, gas and liquid regulators. — Grove Regulator Co., 65th and Hollis St., Emeryville, Calif.

U-867 **Manometers.** 4-page illustrated bulletin describes maker's "Red Line Manometers." Illustrated are well-type manometers, absolute-pressure manometers, indicating flow meters, orifice flanges, and plates.—Trimount Instrument Co., 3119 West Lake St., Chicago 12, Ill.

Flow

U-868 **Pump and Level Control.** 20-page illustrated Bulletin 1534-K is 1952 Condensed Catalog for maker's large line of air volume, float, flow, pressure, and vacuum controllers. Includes features and specifications.—Penn Electric Switch Co., Goshen, Ind.

U-869 **Electronic Flow Meter,** 4-page Bulletin 1050 illustrates and describes maker's flow meter and tachometer unit comprising rotor, magnet, pickup coil, electronic integrator, and totalizer. Includes principles, specifications, and applications.—Potter Aeronautical Co., 87 Academy St., Newark 2, N. J.

Liquid & Material Level

U-870 **Level Control.** 8-page illustrated Bulletin 1650 describes new bubbler-type liquid-level controller which uses compressed-air or gas bubbles to control pumps, valves, etc. Includes principles, features, operation, and applications. — Automatic Control Co., 1005 University Ave., St. Paul 4, Minn.

U-871 **Bin-level Indicator.** 4-page illustrated brochure shows principles and features of maker's "Bin-Vue" materials-level indicator for use with any dry bulk material—powdered, granular, or lumpy. Includes dimensions and suggested wiring schematic.—Convair, 4156 Library Rd., Pittsburgh, Penna.

U-872 **Liquid-level Gages, Valves.** 4-page brochure "Unit 180" illustrates and describes maker's line of liquid-level gages, gage valves, and other specialties. Includes features of reflex gages, transparent gages, remote-reading, jacketed gages, etc.—Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.

Automatic Controllers

U-873 **Contact-making Automatic Controllers.** 4-page Bulletin G-1 describes "Sim-ply-trol" line of indicating electrical instruments with adjustable high-limit, low-limit (or both) contacts and with secondary relays, whereby thermocouples or other primary elements command corrective-action devices. — Assembly Products, Inc., Chagrin Falls 1, Ohio.

U-874 **Contact-type Controllers.** 22-page illustrated booklet describes "Sim-Ply-Trol" contact-type instrument relays. Includes description, circuit diagrams, and information on mounting, cleaning, and servicing. — Assembly Products, Inc., Chagrin Falls, Ohio.

U-875 **Pilots and Controllers.** 20-page revised edition of Pilots and Controllers Section 110 of BS & B Climax control Equipment Catalog shows line of time-cycle controllers, pressure controllers and pilots, manual-remote controllers, vacuum pilots, and safety shut-off pilots. Includes construction, principles, applications, and specifications.—Black, Sivalls, & Bryson, Inc., 7500 E. 12th St., Kansas City 3, Mo.

U-876 **Hydraulic Positioning System.** 12-page Bulletin 157 illustrates and describes new "Hydrotorque" remote-control hydraulic-positioning system using the "Hydroseal" piston-diaphragm power unit. Includes principles, features, specifications, and applications as control element for valves, aircraft rudders, etc.—The Farris Hydrotorque Corp., 610 Commercial Ave., Palisades Park, N. J.

U-877 **Float-actuated Automatic Controllers.** 4-page Bulletin 3100 describes

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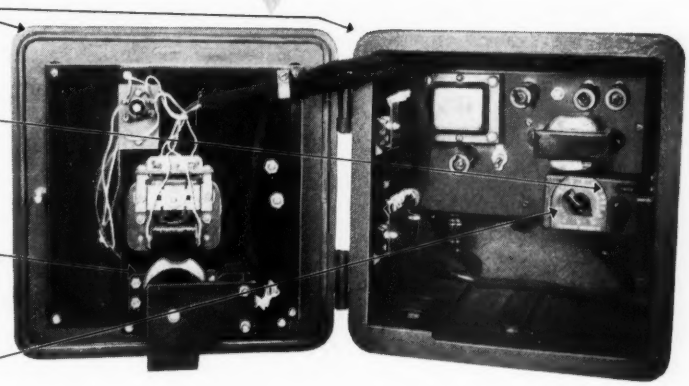

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Computers

U-878 **Electrical Computer.** 4-page Bulletin CEC-1802A describes maker's "Model 30-103 Electrical Computer," designed for rapid solution of as many as 12 simultaneous linear equations. Includes accuracy and time of solution for rapid reduction of mass-spectrometer and infrared-spectrophotometer data.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 8, Calif.

U-879 **Analog Computer.** 12-page booklet opens with general introduction; describes Computer Corp. of America's "IDA" (integro-differential analyzer) which is capable of desk-top mounting and whose operation requires only slightly greater skill than a slide rule. A section explains "General Theory"; another gives "Typical Examples."—Burlingame Associates, 103 Lafayette St., New York 13, N. Y.

Spectrometry

U-880 **Infrared Spectrometry.** 8-page Vol. 3, No. 4 issue of "The Perkin-Elmer Instrument News" contains three articles on infrared: control of oils and phenols in effluent waters, assaying drugs, and "go-no go" inspection of chemicals.—The Perkin-Elmer Corp., Norwalk, Conn.

U-881 **X-ray Spectrometry.** 4-page folder titled "X-ray Techniques Can Halp You Solve Your Materials Problems" contains article reprint on X-ray spectrometry with automatic chart recording as an important tool for materials problems. Includes principles and operation.—Research & Control Instruments Div., North American Philips Co., 750 S. Fulton Ave., Mt. Vernon, N. Y.

U-882 **Infrared Spectrophotometer.** 36-page booklet describes construction and performance of "Model 21" double-beam recording infrared spectrophotometer; includes background sections on infrared spectroscopy and optical null principle.—The Perkin-Elmer Corp., Norwalk, Conn.

Weighing

U-883 **Predetermined-weight Precision Scale.** Form 3272 describes a 2000-mg. capacity "Shadowgraph" sensitive to 1 mg. and said to be three to four times as fast as an ordinary balance; designed for industrial and arsenal uses; commodity container is a 1-inch aluminum pan with pouring spout and handle.—The Exact Weight Scale Co., Columbus 8, Ohio.

U-884 **Truck Axle-load Scales.** 8-page Form 682 describes ball-bearing heavy-duty axle-load scales available in various types, including full-capacity beam, type recording beam, balance indicator, tape-drive cabinet dial, "Weightograph" projection, etc.—The Howe Scale Co., Rutland, Vermont.

U-885 **Analytical Balance.** 4-page brochure illustrates and describes "Sartorius Selecta" analytical balance with capacity of 200 grams and sensitivity of 1/20 mg. Includes features and specifications.—General Scientific Equipment Co., 3011 Dixwell Ave., Hamden 14, Conn.

Optical

U-886 **Toolmaker's Microscope.** 8-page Bulletin 147-50 presents detailed optical and mechanical description of new model of toolmaker's microscope; also of numerous accessories. Last page tabulates specifications in full details.—The Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill.

U-887 **Jeweler's Lathe Microscope.** Data Unit 209 describes an instrument-maker's wide-field microscope attachable to any standard jeweler's lathe; available in 20X or 40X magnifications, with or without reticle.—Pacific Transducer Co., 11921 Pico Blvd., Los Angeles 64, Calif.

U-888 **Optical Level.** 4-page Catalog 30 describes optically precise level for measuring flatness, straightness and parallelism for checking and leveling machine beds, surface and lapping plates, rolls, jigs, fixtures, etc.—F. T. Griswold Mfg. Co., W. Lancaster Ave., Wayne, Pa.

Inspection & Testing

U-889 **Portable Hardness Tester.** 4-page illustrated brochure describes portable "A-H Comparator Tester" for testing hardness of metals and various properties of other materials.—A-H Co., 220 E. Grand River Ave., Brighton, Mich.

U-890 **Insulation Testers.** 2-page illustrated brochure covers maker's "Megger" line of insulation-resistance testers.—James G. Biddle Co., 1316 Arch St., Phila. 7, Penna.

U-891 **Sonic-principle Tester.** 2-page bulletin describes a new type of instrument for non-destructive physical testing, employing sonic-resonance principle with a stylus-like exciter, a non-contact microphone, and an oscilloscope for displaying resonance pattern.—Saturn Electronics Co., 8237 Witkop Ave., Niagara Falls, N. Y.

U-892 **Automatized Thermal Studies.** 4-page Bulletin 2205 describes new "Meltometer" for automatic determination of melting-, softening-, dehydration-, and solidification-point, etc.—American Instrument Co., Inc., Silver Spring, Md.

U-893 **Rotary Accelerator.** 4-page bulletin describes a 16-inch-table rotary accelerator for calibrating or testing instruments and components under controlled centrifugal accelerations from 0.1 to 100 G.—Statham Development Corp., 12411 W. Olympic Blvd., Los Angeles 64, Calif.

U-894 **Granite Surface Plates.** 2-page illustrated Data Sheet Sec. F5 gives features, specifications, and ad-

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the new HONEYWELL PRESSURE PILOT

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Differential screw permits accurate adjustment of set point; no gears or other cumbersome devices.

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Simplified design speeds cleaning, repair or replacement of sub-assemblies.

A PRESSURE controller of unusual ruggedness and versatility, the Honeywell Pressure Pilot is an ideal means of regulating hydraulic systems, pipe lines, pump outlets and other applications where more expensive indicating and recording instruments are not warranted.

It utilizes a Bourdon tube sensing element, flapper-and-nozzle control assembly, and a pneumatic booster relay . . . all combined in a sturdy, low-cost unit capable of remarkably accurate control.

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NEW LITERATURE

vantages of granite surface plates for precision gaging.—The DoAll Co., Des Plaines, Ill.

U-895 **Earth-resistance Tester.** 2-page Bulletin 159 illustrates and describes new "Model JP Ground-Ohmer" for soil-resistance measurements. Includes principles, features, and typical applications.—Herman H. Sticht Co., Inc., 27 Park Pl., New York, N. Y.

U-896 **Dial Gages.** 40-page illustrated Catalog D covers maker's line of gages, including bore gages, dial snap gages, dial groove and groove location gages, and dial pitch diameter gages. Includes principles, features, and operation.—Nilsson Gage Co., Inc., Poughkeepsie, N. Y.

U-897 **Tin-coating Gage.** 8-page booklet titled "X-ray Tin Coating Gage" is reprint explaining operating principles and application details covering X-ray instrument used for measuring thickness of coatings on steel plate.—Research & Control Instruments Div., North American Philips Co., Inc., 750 So. Fulton Ave., Mt. Vernon, N. Y.

U-898 **Textiles, Paper Testers.** 20-page Bulletin 1400 illustrates and describes maker's line of test instruments for papers, textiles, thin metals, and plastics. Includes features and specifications of instruments for testing stiffness, smoothness, porosity, permeability, sizing, and absorptiveness.—W. & L. E. Gurley, Troy, N. Y.

Electrical & Electronic Instruments

U-899 **Recording Potentiometer.** 6-page folder Circular P-3-A announces new recording potentiometer. Includes features, construction, maintenance factors and advantages.—Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

U-900 **Electrical Indicating Instruments.** 20-page June issue of "The Frontier" contains 6-page article on characteristics of electrical movements; other articles are on magnetic recording and air pollution.—Armour Research Foundation, Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

U-901 **Oscilloscope.** 2-page Form 670 illustrates and describes new 5-inch "Model 670" oscilloscope with d-c. amplifiers. Includes features and specifications.—The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, Ohio.

U-902 **Phase Meter.** 1-page bulletin gives specifications of new "Type 404 Advancetron" phase meter said to be the first commerically available instrument giving direct reading in degrees between two alternating voltages of any waveform, symmetrical or unsymmetrical, from 100 kc. down to zero.—Advance Electronics Co., P. O. Box 394, Passaic, N. J.

U-903 **Unlimited-memory Oscilloscope.** 4-page Bulletin 11-9020 describes new "Model MS-10A" of maker's

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"Memoscope" for research work and production testing where waveshape recording is essential.—Millivac Instrument Corp., P.O. Box 997, Schenectady, N. Y.

U-904 **Low-frequency Oscillator.** 4-page bulletin describes "Model L" two-amplifier bridge-stabilized source of power covering frequency range from 0.01 to 100 cps. in eight overlapping ranges.—Southwestern Industrial Electronics Co., 2831 Post Oak Road, Houston 19, Texas.

U-905 **Impedance Measurement.** 4-page July 1952 issue of "-hp- Journal" features an article "A Novel Impedance-measuring System Using Standard -hp- Instruments" which explains how to measure extremely wide ranges of **L** and **C** as well as moderate ranges of **R** and **Z**.—The Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif.

U-906 **Recording Cameras for Oscilloscopes.** 2-page announcement illustrates and describes four new cameras: "Type 295" for single-transient recording, "Type 296" for single-frame recording, "Type 297" for finished print (Polaroid-Land) recording, and "Type 321" for simplified moving-film recording.—Instrument Div., Allen B. Du Mont Laboratories, Inc., 1000 Main Ave., Clifton, N. J.

U-907 **Linear-motion Potentiometer-rheostats.** 8-page catalog describes and gives detailed dimensions and characteristics of voltage-dividing resistors which provide precise electrical indications of mechanical displacements. Units are serially numbered and an individual calibration record is furnished with each. Any desired travel from a fraction of an inch to over six inches.—Bourns Laboratories, 6135 Magnolia Ave., Riverside, Calif.

U-908 **Carrier Amplifier.** 4-page Bulletin CEC-1522A illustrates and describes maker's "Type-118 Carrier Amplifier," a high-quality 4-channel system for use with many available pickups. Includes features and typical applications.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 8, Calif.

U-909 **Admittance Meter.** 4-page Form 777-B illustrates and describes "Type 1602-A Admittance Meter" for impedance measurements from 50 to 1500 Mc. Includes features, specifications, and typical setups for measuring impedance, admittance, VSWR, reflection coefficient, etc.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

U-910 **Multi-waveform Generator.** 2-page illustrated brochure describes new "TEC Syncroplex" that generates sawtooth, square-wave, variable-width pulses, differentiated pulses, integrated pulses, width- and time-modulated pulses, and gated-pulse waveforms. Includes specifications.—Television Equipment Corp., 238 William St., New York 38, N. Y.

U-911 **A-c. Volt-ammeter.** 2-page illustrated bulletin describes new "Type AC-1" clamp-type hand-size a-c. volt-ammeter. Includes features, specifica-

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tions, and applications.—Columbia Electric Mfg. Co., 4519 Hamilton Ave., N.E., Cleveland 14, Ohio.

U-912 **Line Regulators.** Illustrated brochure contains electrical specifications of maker's line of "Isotronic" a-c. line regulators.—Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn.

U-913 **Ground-resistance Measurement.** 4-page Vol. 8 No. 2 issue of "Biddle Instrument News" features article on "Treasure Hunting with a Megger Ground Tester." Also articles on "Frahm" resonant-reed frequency-sensitive relay and transformer turns-ratio test set.—James G. Biddle Co., 1316 Arch St., Phila. 7, Penna.

U-914 **Frequency Meter.** 2-page Bulletin 55221 illustrates and describes new "MFM" micrometer frequency meter for frequencies from 100 kc. to 175 Mc. Includes features, principle and specifications.—Lampkin Laboratories, Inc., Bradenton, Fla.

U-915 **Laboratory Standards.** 8-page Vol. 19 No. 4 issue of "Electrical Measurements" features detailed descriptions of (1) new d-c. standard volt-amp-milliammeter with built-in self-checking potentiometer circuit and (2) new thermocouple-type a-c. and d-c. volt-amp-milliammeter with self-checking feature.—Sensitive Research Instrument Corp., 9-11 Elm Ave., Mt. Vernon, N. Y.

U-916 **Decade Inductor Units.** Bulletin D-2 describes and tabulates characteristics of "700 Series," comprising four new ten-step units with ranges from 10×0.001 henry to 10×1 henry.—Hycor Co., Inc., 11423 Vanowen St., North Hollywood, Calif.

Magnetic Amplifiers

U-917 **Controllable Inductors.** 8-page catalog and 4-page data sheet describes and gives detailed characteristics (with graphs) of "Increductors"—electrically-variable inductors sometimes called magnetic amplifiers. Inductance range of standard models is at least 160 to 1; of special models, as high as 600 to 1. Units come in sealed cans.—C. G. S. Laboratories, Inc., 391 Ludlow St., Stamford, Conn.

U-918 **Twin-T units for Feedback Systems.** 4-page bulletin describes and gives specifications of: "Kay-Lab Twin-T Peaked Amplifier" and "Kay-Lab Twin-T Servo Stabilizer" for servomechanisms; and "Kay-Lab Twin-T Filter" for VTVM or CRO hum attenuation, etc.—Kalbfell Laboratories, P.O. Box 1578, San Diego 10, Calif.

U-919 **Magnetic Modulator.** 2-page illustrated brochure announces and describes new "IMM 182" magnetic modulator for converting weak d-c. signals into 400-cps. a-c. power signals. Includes features and specifications.—General Magnetics, 135 Bloomfield Ave., Bloomfield, N. J.

Power Supplies

U-920 **Power Supplies.** 4-page Form CC-3-2500 illustrates and describes 17 models of electronically-regulated power supplies with outputs from 7.5 to 500 watts, including specifications. Also described are maker's wide-band d-c. amplifier and WOW meter.—Furst Electronics, 3322 W. Lawrence Ave., Chicago 25, Ill.

U-921 **Power Supplies.** 20-page catalog describes an extensive line of voltage-regulated power supplies for various purposes; also electronic circuit panel for teaching and experimenting; and charts.—Kepco Laboratories, Inc., 131-38 Sanford Ave., Flushing 55, N. Y.

U-922 **Power Supplies.** 4-page condensed brochure presents brief descriptions of sixteen voltage-regulated power supplies.—Kepco Labs, Inc., 131-38 Sanford Ave., Flushing 55, N. Y.

Electrical & Electronic Components

U-923 **Electronic Components.** 48-page illustrated Catalog B2 provides condensed, comprehensive listing of maker's large line of "Amphenol" components—multi-contact connectors of all types, transmission lines, antennas, sockets, etc.—American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.

U-924 **Insulated Thermocouple Wires.** 2-page Bulletin 5600 introduces three new thermocouple wires suitable for use in temperatures varying from minus 20 to plus 2000 F.; lists engineering data and applications. Station 213, Brown Instruments Div., Wayne & Windrim Aves., Philadelphia 44, Pa.

U-925 **Chopper-amplifier.** 2-page illustrated brochure announces and describes new "Model 300 Universal Chopper Amplifier" for microvolt signals from 0 to 500 cps. and with chopper action of 5000 per sec. Includes features and tentative specifications.—Keithley Instruments, 3868 Carnegie Ave., Cleveland 15, Ohio.

U-926 **Connector Clip.** 1-page announcement describes new TV combination clip which can be used on all sets without removing back or holding set out from wall.—Rytel Electronics Mfg. Co., 9820 Irwin Ave., Inglewood, Calif.

U-927 **High-vacuum Rectifier.** 2-page illustrated data sheet describes "Los Gatos Type 8020" high-vacuum rectifier; gives operating characteristics for both rectifier and surge-limiting diode operation.—Lewis & Kaufman, Inc., 110 El Rancho Ave., Los Gatos, Calif.

U-928 **Hydrogen Thyratron.** 4-page Bulletin 3C45 illustrates and describes new "Type 3C45" triode hot-cathode hydrogen thyratron for pulsing service. Includes characteristics and operating data.—Tube Dept., RCA, Harrison, N. J.

U-929 **Carbon-film Resistors.** 4-page bulletin illustrates and describes maker's 1-percent-precision deposited-carbon "Stablohm" resistors. Includes construction, dimensions, features, and characteristics.—Chase Resistor Co., 9 River St., Morristown, N. J.

U-930 **Variable Air Capacitors.** 12-page illustrated "52 Capacitor Catalog" covers maker's large line of standard

variable air capacitors. Includes features, construction, and specifications. —Hammerlund Mfg. Co., Inc., 460 W. 34th St., New York 1, N. Y.

U-931 **Push-button Switch.** Illustrated Data Sheet 60 describes new "IPB3" push-button miniature switch assembly. Includes features, dimensions, and electrical ratings.—Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

U-932 **Subminiature Paper Capacitors.** 2-page illustrated brochure gives performance characteristics, test specifications, features, dimensions, and prices of new "Type AQ" subminiature paper capacitors for operation to 125 deg. C.—Astron Corp., 255 Grant Ave., E. Newark, N. J.

U-933 **Terminals and Connectors.** 8-page Vol. 27 No. 2 issue of "The General Radio Experimenter" features 7-page article on standardized terminals, connectors, patch cords, and test leads. —General Radio Corp., Cambridge, Mass.

U-934 **Miniature Capacitors.** 4-page brochure illustrates and describes new line of vitreous-dielectric miniature capacitors. Includes features, characteristics, and uses.—Vitramon, Inc., Box 544, Bridgeport 1, Conn.

U-935 **Half-wave Rectifier.** Technical Data Sheet 12AX4-GT lists data and operating considerations for new "Type 12AX4-GT" half-wave vacuum rectifier tube.—Tube Dept., RCA, Harrison, N. J.

U-936 **Power Pentode.** 4-page illustrated Bulletin 6CL6 covers new "Type 6CL6" power pentode, a 9-pin miniature final-video stage. Includes characteristics, operating data, and dimensions.—Tube Dept., RCA, Harrison, N. J.

U-937 **Rotary-switch Kits.** 2-page illustrated "Industrial Bulletin C, Form 42-138" describes new kits containing parts for assembling standard or special rotary-switch arrangements. Includes details and prices on standard and deluxe sections.—Centralab Div., Globe-Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.

U-938 **Capacitors, Vibrators.** 16-page Vol. 17, No. 7 issue of "The CD Capacitor" contains 3-page article on safe use of selenium rectifiers. Also descriptions of maker's ceramic capacitors, electrolytic capacitors, and vibrators.—Cornell-Dubilier Electric Corp., Hamilton Blvd., S. Plainfield, N. J.

U-939 **Miniature Power Connectors.** 2-page illustrated Catalog Sheet P7-16 describes new line of miniature precision multi-contact connectors for severe instrument service. Includes features, specifications, and nomenclature. —DeJur Amsco Corp., 45-01 Northern Blvd., L.I.C. 1, N. Y.

U-940 **Fixed Composition Resistors.** 4-page illustrated Form 3M describes maker's line of fixed composition resistors with JAN-R-11 specifications. Includes construction, characteristics, and price schedule.—Stackpole Carbon Co., St. Marys, Penna.

U-941 **Industrial Capacitors.** 8-page Catalog 1117 covers Series "D" "Sta-

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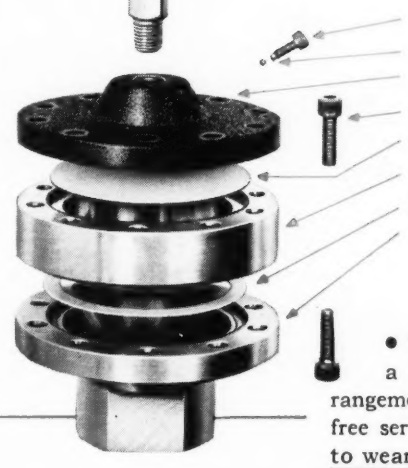

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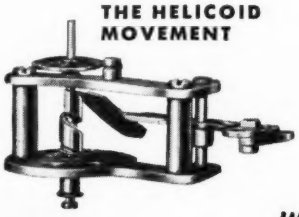

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belex" capacitors, Types "S," "D," "B," "G" and "T," presents detailed characteristics in seven graphs whereby users can select units with full knowledge in advance. Construction details also given fully.—Industrial Condenser Corp., 3243 N. California Ave., Chicago 18, Ill.

U-942 **Printed-circuit Components.** 4-page booklet introduces a number of new miniature and subminiature units from simple "Filplates" to complete 3-stage speech amplifiers.—Centralab Div., Globe-Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.

U-943 **Toroidal Power Transformer.** 2-page Form 11-1246 describes "Model MT-1001 Lofyld" power transformer for high-quality amplifiers, which eliminates magnetic hum and offers other advantages.—Millivac Instrument Corp., P.O. Box 997, Schenectady, N. Y.

U-944 **Toroidal Inductors.** 4-page Bulletin IL-P4 lists precision-wound high-Q toroidal inductors; includes Q curves and other design data for representative standard values of the various coil types.—Lenkurt Electric Sales Co., 1118 County Road, San Carlos, Calif.

Valves

U-945 **Control-valve Design.** 16-page Technical Paper No. 106, "New Techniques in Control Valve Design," by R. B. Werey, is a provocative discussion in which the author challenges many present-day standards and outlines specific recommendations.—Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.

U-946 **Air Valves.** 8-page illustrated Bulletin 15M-7-52 describes maker's line of air-control valves, including 2-way, 3-way, 4-way, tandem, neutral, solenoid-pilot, and diaphragm-operated types. Includes construction and features.—Valvair Corp., 454 Morgan Ave., Akron 11, Ohio.

U-947 **Diaphragm Control Valves.** 26-page revised edition of Section 105 of BS & B Climax Control Equipment Catalog covers large line of high-pressure, single-port, three-way, bellows-sealed, duplex, low-pressure, reversible-action, and butterfly-valve types of diaphragm control valves. Includes features, construction, and specifications.—Black, Sivalls, & Bryson, Inc., 7500 E. 12th St., Kansas City 3, Mo.

U-948 **Precision Check Valves.** 4-page Form S-2021 illustrates and gives detailed characteristics of "Circle Seal" check valves ("Standard" and "Ultra-sensitive" types) said to provide complete sealing efficiency at high and low pressures and minimal resistance to flow; usable for numerous fluids from air to crude oils.—James-Pond-Clark, 2181 East Foothills Blvd., Pasadena 8, Calif.

Materials

U-949 **Hard-facing Alloys.** 12-page "Hard-facing Manual No. 77" features a two-page tabulation of characteristics of nickel-base and iron-base alloys; also a two-page guide for typical applications.—Wall Colmonoy Corp., 19345 John R Street, Detroit 3, Mich.

U-950 **Magnesium Data.** 16-page August issue of "The Magazine of Magnesium" contains articles on current uses; also a full-page tabulated "Index to Chemical and Electrochemical Treatments for Magnesium Alloys."—Brooks and Perkins Inc., 1950 W. Fort St., Detroit 16, Mich.

U-951 **Insulating Plastics.** 4-page July-August issue of "Amphenol Engineering News" features instrumentation applications of Amphenol products and Teflon.—American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.

U-952 **Alloy Steel Specifications.** Cardboard chart shows chemical analysis for each of 70 Military, AN, Army, Navy, Aeronautical and Federal specifications; lists specified forms (sheets, bar, tubing, etc.) and nearest corresponding SAE, AISI and AMS type numbers.—Peter A. Frasse and Co., Inc., 17 Grand St., New York 13, N. Y.

Miscellaneous

U-953 **Instrumentation Service.** 12-page profusely-illustrated booklet, "Remote Measurement and Automatic Data Conversion," outlines company's consultation, research and development services, and production facilities.—Applied Science Corp. of Princeton, P.O. Box 44, Princeton, N. J.

U-954 **TV Camera Chain.** 20-page Bulletin TR-193 (available to TV personnel and others in TV and radio industry) gives detailed description and performance characteristics of "Model TA-124-E" universal image orthicon TV camera chain.—TV Transmitter Div., Allen B. Du Mont Laboratories, Inc., Clifton, N. J.

U-955 **Fluorescent Leak Detector.** 4-page brochure describes new "Raymaster" leak detector that uses fluorescent liquid and long-wavelength ultraviolet exploring lamp. Includes technique, features, specifications, and typical applications.—George W. Gates & Co., Franklin Square, L. I., N. Y.

U-956 **Engraving Machine.** 6-page Bulletin 23016 describes "Model 106 Engraver" for nameplates, dials, scales, lenses, etc., made of metals, plastics, wood, glass, etc. Machine is simple to set-up and can be operated by untrained personnel. Bulletin also describes accessories such as sets of letters and numerals, etc.—Green Instrument Co., Inc., 385 Putnam Ave., Cambridge 39, Mass.

U-957 **Screw-holding Screwdriver.** Folder describes new "H.J.J. Screwdriver" with twin bits that expand in screw-head slot to hold screw; and which does not release screw until it takes hold.—The H.J.J. Company, 268 Marlow Ave., Oakland 5, Calif.

U-958 **Isometric Template.** 4-page folder describes a new draftsman's template containing 38 ellipses and fea-

turing three slots which form the axes of the isometric system.—RapiDesign, Inc., Box 592, Glendale, Calif.

U-959 **Resistance Soldering.** 6-page brochure illustrates and describes maker's line of resistance-soldering equipment for steel, aluminum, brass, etc. Includes principles, features, and specifications.—Sunrise Products Co., Hawthorne, N. J.

U-960 **Flaring Tools, Vise.** 2-page illustrated Bulletin 3004 describes new 37-degree flaring tools, including sizes and operation. Also sawing vise for tubing.—Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago 7, Ill.

U-961 **Pulsation Dampener.** Illustrated Bulletin 317 announces and describes new air-flow snubber and pulsation dampener. Includes construction, operation, advantages, and specifications.—King Engineering Corp., Ann Arbor, Mich.

U-962 **Air, Gas Dryers.** 4-page Bulletin 16.0.080 illustrates and describes "Hydryer" adsorption-type dryers for gases, air, or liquids. Includes models, features, specifications, and other gas equipment.—J. F. Pritchard & Co., 908 Grand Ave., Kansas City 6, Mo.

U-963 **Permanent Magnets.** 20-page illustrated Bulletin PM 100 covers maker's large line of stocked "Alnico" permanent magnets. Includes properties, shapes, holders, patterns, magnetizers, and conversion tables.—Carboloy Dept., General Electric Co., Detroit 32, Mich.

U-964 **Draftsman's Compasses.** 6-page folder illustrates and describes maker's standard bow compasses and also "Omicron Beam Compasses" with 72-inch-radius capacity. Includes features and operation.—Omicron Co., P. O. Box 907, Glendale, Calif.

U-965 **Pressure-sensitive Tape.** 4-page brochure covers features of "Tel-A-Pipes" pressure-sensitive tape for marking and identifying cable, conduit, and pipe.—Westline Products Div., Western Lithographic Co., 600 E. Second St., Los Angeles 54, Calif.

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U-966 **Safety Instrumentation.** 8-page Vol. 11 No. 6 issue of "Automobile Facts" features articles on safety instrumentation of automotive vehicles, quality control in automotive plants, and others.—Automobile Manufacturers Association, 320 New Center Bldg., Detroit 2, Mich.

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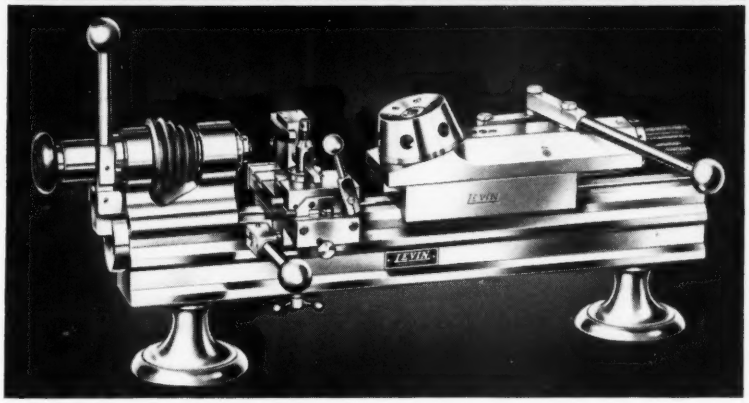

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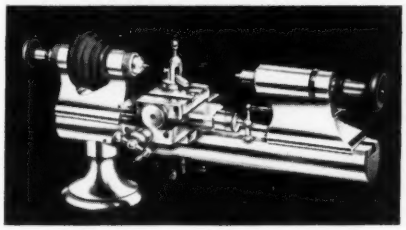

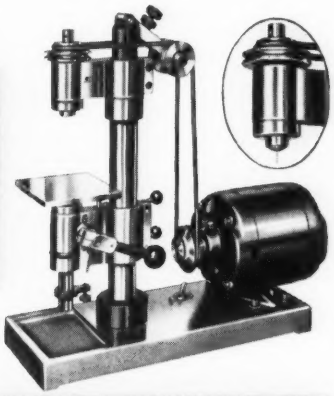

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